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June 1992

LETTER OF PROMULGATION

1. NWP 55-6-OV10A/D, Vol. I (Rev. E) (NAVAIR 01-60GCB-1T), the OV-10A/D TACTICAL MANUAL, is an Unclassified publication which is effective upon receipt. It supersedes NWP 55-6-OV10A/D, Vol. I (Rev. D) (NAVAIR 01-60GCB-1T) of February 1989, which shall be destroyed without report.

2. Aircraft tactical manuals provide the latest and most accurate tactical information to aircrews and tactical commands. These manuals are designed to promote the development of efficient and sound tactical doctrine and to eliminate the need for promulgation of doctrine by individual squadrons. The tactics published herein are to be considered as a guide to better operations, not as the only way and final authority in tactical evolutions. It is both desirable and necessary that new ideas and new techniques be expeditiously evaluated and incorporated if proven to be sound. To this end, Operational Commanders should encourage innovative thought and the use of effective tactics not reflected herein. These manuals are compiled using Fleet inputs and are kept current to achieve maximum combat readiness. To provide the latest data, Navy and Marine Corps Fleet/Type/Air Wing Squadron Commanders are directed to review these procedures on a continuing basis and submit recommended modifications as outlined under "Change Recommendations."

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June 1992

PUBLICATION NOTICE

ROUTING

1. NWP 55-6-OV10A/D, Vol. I (Rev. E), the OV-10A/D TACTICAL MANUAL (U), is available in the Naval Warfare Publications Library.

2. This publication is updated in its entirety.

Naval Warfare Publications Custodian

Naval warfare publications must be made readily available to all users and other interested personnel within the U.S. Navy.

Note to Naval Warfare Publications Custodian

This notice may be duplicated for routing to cognizant personnel to keep them informed.

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INTERIM CHANGE SUMMARY

The following Interim Changes have been canceled or previously incorporated in this manual:

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SUMMARY OF APPLICABLE TECHNICAL DIRECTIVES

Information relating to the following recent technical directives has been incorporated in this manual

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BIBLIOGRAPHY

1. ALLIED PUBLICATIONS

ATP 4, Allied Spotting Procedures for Naval Gunfire Support
ATP 27, Offensive Air Support Operations
ATP 33, NATO Tactical Air Doctrine
ATP 37, Supporting Arms in Amphibious Operations

2. JOINT PUBLICATIONS

JCS Pub 1-02, DOD Dictionary of Military and Associated Terms
JCS Pub 12, Tactical Command and Control Procedures for Joint Operations (Vol. II, Procedures and Formats)

3. LANDING FORCE MANUALS

LFM 01, Doctrine for Amphibious Operations

4. FLEET MARINE FORCE MANUALS

FMFM 3-3, Helicopterborne Operations
FMFM 5-1, Marine Aviation
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FMFM 5-40 Offensive Air Support
FMFM 5-41 Close Air Support
FMFM 7-1, Fire Support Coordination
FMFM 7-2, Naval Gunfire Support
FMFM 7-4, Field Artillery Support

5. U.S. NAVY PUBLICATIONS

NWP 0, Naval Warfare Documentation Guide
NWP 3, Naval Terminology
NWP 12-2, Tactical Threat to Naval Surface Forces
NWP 17, Airspace Control Over the Combat Zone
NWP 22-1, The Amphibious Task Force Plan (Annex F, Air Operations)
NWP 55-3-A4M Tactical Manual (NAVAIR 01-40AVM-1.1T)
NWP 55-3-A4/TA4 Tactical Manual (NAVAIR 01-40AV-1T)
NWP 55-3-A6 Tactical Manual (NAVAIR 01-85ADF-1T.1)
NWP 55-3-AV8B Tactical Manual (NAVAIR A1-AV8BB-TAC-000)
NWP 55-3-AH1 Tactical Manual (NAVAIR 01-110HC-1T)
NWP 55-4-EA6B Tactical Manual (NAVAIR 01-85ADC-1T)
NWP 55-5-F4 Tactical Manual (NAVAIR 01-245 FDB-1T.1)
NWP 55-9-ASH, Assault Support Helicopter Tactical Manual (NAVAIR 01-1ASH-1T)

6. U.S. ARMY FIELD MANUALS

FM 1-1, Terrain Flying
FM 30-20, Aerial Surveillance — Reconnaissance, Field Army
FM 30-40, Handbook on Soviet Ground Forces
FM 90-1, Employment of Army Aviation Units in a High Threat Environment

7. U.S. AIR FORCE PUBLICATIONS

AFM 2-1, Tactical Air Operations — Counter Air, Close Air Support, and Air Interdiction
AFM 2-2, Air Operations in Conjunction With the Amphibious Operations
TACM 1-1, Tactical Air Forces in Joint Operations
TACM 2-4, Tactical Air Control Party

8. OTHER PUBLICATIONS

MCO 3120.3, The Organization of Marine Air-Ground Task Forces
NWC TP 5537, A Study of Airborne Forward Air Control Operations (Naval Weapons Center, China Lake)

GLOSSARY

A

accommodative eye fatigue. Fatigue associated with the eyes resulting from continuously and automatically focusing and refocusing to offset binocular misadjustment or differences in monocular resolution.

acquisition. The process of locating a target with a search radar such that a tracking radar can take over and begin tracking the target.

active homing guidance. A system of homing guidance wherein both the source for illuminating and the receiver for detecting the energy reflected from the target, as the result of illuminating the target, are carried within the missile.

add. A correction used by an observer or a spotter to indicate that an increase in range along a spotting line is desired.

adjust fire. An order or request to initiate an adjustment. A method of control transmitted in the call for fire by the observer or spotter to indicate that he will control the adjustment.

advance force. A temporary organization within the amphibious task force that precedes the main body to the objective area. Its function is to participate in preparing the objective for the main assault by conducting such operations as reconnaissance, seizure of supporting positions, minesweeping, preliminary bombardment, underwater demolitions, and air support.

airborne alert. A state of aircraft readiness wherein combat-equipped aircraft are airborne and ready for immediate action. It is designed to reduce reaction time and to increase the survivability factor.

airborne radio relay. A technique employing aircraft fitted with radio relay stations for the purpose of increasing the range, flexibility, or physical security of communication systems.

airburst. An explosion of a bomb or projectile above the surface as distinguished from an explosion on contact with the surface or after penetration.

air corridors. Restricted air routes of travel specified for use by friendly aircraft and established for the purpose of preventing friendly aircraft from being fired on by friendly forces. See restrictive fire plan.

air defense. All measures designed to nullify or reduce the effectiveness of hostile air action.

air defense artillery (ADA). Weapons, including guns and surface-to-air missiles and support equipment, for engaging air targets from the ground. Weapons are classed as light: 20 to 57 mm, medium: 58 to 99 mm, heavy: 100 mm or greater.

air defense sectors. Air sectors within the MAGTF'S sector of responsibility constructed to defend the MAGTF against airborne threat platforms. The air defense sector is characterized by the vital area, the destruction area, the surveillance area, and weapons engagement zones (WEZ).

air drop. The unloading of personnel or material from aircraft in flight.

air fire plan. A plan for integrating and coordinating tactical air support of ground forces with other fire support.

airhead. A designated area in a hostile or threatened territory that, when seized and held, ensures the continuous air landing of troops and material and provides the maneuver space necessary for projected operations. Normally it is the area seized in the assault phase of an airborne operation.

air movement table. A table prepared by a ground force commander in coordination with an air force commander. This form, issued as an annex to the operation order:

1. Indicates the allocation of aircraft space to elements of the ground units to be airlifted

2. Designates the number and type of aircraft in each serial

3. Specifies the departure area, time of loading, and takeoff.

air officer. At the battalion level, an officer who functions as the chief advisor to the battalion commander

on all air operation matters. He also supervises the training and operation of the two battalion forward air control parties (FMRP 0-14).

airspace coordination area (ACA). A safety measure for friendly aircraft that establishes airspace within which support aircraft can operate with reasonable safety from friendly fires by restricting all conventional surface fires between prescribed maximum altitudes within a specific area during a stated time interval.

air superiority. That degree of dominance in the air battle of one force over another that permits the conduct of operations by the former and its related land, sea, and air forces at a given time and place without prohibitive interference by the opposing force.

air support radar team (ASRT). A subordinate operational component of a tactical air control system that provides all weather, ground-controlled, precision flightpath guidance and weapon release.

air supremacy. That degree of air superiority wherein the opposing air force is incapable of effective interference.

air threat environment. The condition(s) that relates to the enemy's air defense capability against airborne friendly aircraft. There are three general levels of air threat environment:

1. Low. An air threat environment that permits combat operations and support to proceed without prohibitive interference. Associated tactics and techniques do not normally require extraordinary measures for preplanned or immediate support. Target/objective engagement is enhanced by:

(a) Effective communications

(b) Accurate target/objective indentification

(c) Reattacks if applicable (limited only by aircraft time on station and ordnance on board).

2. Medium. An air threat environment in which the specific aircraft performance and weapon systems capability allow acceptable exposure time to enemy air defenses. This air threat environment in which the enemy may have limited radar and/or electro-optical (EO) acquisition capability at medium ranges, but the air defense system is not supported by fully integrated fire control systems. Medium air threat environments normally allow medium altitude missions/attack/deliveries with low probability of engagement by enemy air defenses.

3. High. An air threat environment created by an opposing force possessing air defense combat power including integrated fire control systems and electronic warfare (EW) capabilities that would seriously diminish the ability of friendly forces to provide necessary air support. This air threat environment might preclude missions such as immediate CAS, as the requirement for effective radio communications and coordination may not be possible. The high air threat environment may include but is not limited to:

(a) Command and control network

(b) Mobile and/or stationary surface-to-air missiles (SAM's)

(c) Early warning radars

(d) Electronic warfare (EW)

(e) Integrated (AAA) fire control systems

(f) Intercepter aircraft

(g) Wartime reserve modes.

albedo. The ratio of incident to reflected light; that is, the ratio of light that strikes a surface to that light reflected from the surface.

all available. A command or request to obtain the fire of all artillery able to deliver effective fire on a given target.

allocation. The translation of the apportionment into total numbers of sorties by aircraft type available for each operation/task.

amphibious objective area (AOA). A defined geographic area within which is located the area or areas to be captured by the amphibious task force. It is delineated in the initiating directive in terms of sea, land, and airspace.

amphibious task force (ATF). The task organization formed for the purpose of conducting an amphibious operation. The amphibious task force always includes navy forces and a landing force with their organic aviation.

angle off. An abbreviated expression for angle off the tail; this is the angle between the attacker's line of sight to target aircraft and an imaginary line extended

from the tail of the target aircraft. Never more than 180°, it is an important measure because most air-to-air weapons are best employed with the attacker's nose roughly aligned with the target's nose. The classic 6 o'clock position would yield 0° angle off. An offensive advantage can be gained by reducing the angle off an adversary. Thus, to help defend against an aggressor, one should attempt to increase the angle off.

angle rate bombing system (ARBS). A method of computer bombing used by tactical attack aircraft.

angle T. The angle formed at the target by the intersection of the gun-target line and the observer-target line.

antiradiation missile (ARM). A missile that homes passively on a radiation source.

apparent disk. The surface area of the moon that can be seen from the Earth as it is illuminated by reflected light from the sun.

apportionment. The determination and assignment of the total expected effort by percentage and/or by priority that should be devoted to the various air operations and/or geographic areas for a given period of time.

area of influence. A geographic area wherein a commander is directly capable of influencing operations by maneuver or fire support systems normally under his command or control.

area of interest. That area of concern to the commander, including the area of influence, areas adjacent thereto, and extending into enemy territory to the objectives of current or planned operations. This area also includes areas occupied by enemy forces who could jeopardize the accomplishment of the mission.

area of responsibility. A defined area of land in which responsibility is specifically assigned to the commander of the area for the development and maintenance of installations, control of movement, and the conduct of tactical operations involving troops under his control along with parallel authority to exercise these functions.

area search. Reconnaissance or search of a specific area to provide new or updated information on general or specific situations and/or activities.

area target. A target consisting of an area rather than a single point.

armed reconnaissance. A mission with the primary purpose of locating and attacking targets of opportunity in assigned general areas or along assigned lines of communications and not for the purpose of attacking specific briefed targets.

armstrong. The term, peculiar to the air support radar team (ASRT), indicating both the command and response for arming and fuzing circuit activation.

artillery fire plan table. A presentation of planned targets giving data for engagement. Scheduled targets are fired in a definite time sequence. The starting time may be on call, at a prearranged time, or at the occurrence of a specific event.

artillery preparation fire. Artillery fire delivered before an attack to disrupt communications and disorganize the enemy's defense.

aspect angle. The angle measured form the nose of the attacker's aircraft to the aircraft being attacked. Never more than 180°, aspect angle describes the target picture seen by an aggressor pilot.

astigmatism . An optical error characterized by an unequal curvature in one or more of the eye's refractive surfaces (most often the cornea). This condition causes an object to come to focus at two points on the visual axis instead of one point.

at my command. The command used when it is desired to control the exact time of delivery of fire by the requesting agency.

attack heading. The assigned magnetic compass heading to be flown by aircraft during the delivery phase of an airstrike. Also referred to as run-in heading.

attack position. Last covered and concealed position used by an attack helicopter to deploy and move into firing position for target engagement.

automatic brightness control. Protective feature associated with second and third generation I^2 devices; protects observer from bright flashes by holding output brightness to a preset level.

authenticate. A challenge given by voice or electrical means to attest to the authenticity of a message or transmission.

aviation communication electronic operating instruction (ACEOI). The aviation portion of the overall instruction that contains technical guidance for the establishment of communications. It amplif-

tes the communication SOP by providing technical instructions to coordinate and/or control the various communication means and functions within a command. Additionally, it contains all unit call signs and frequencies as required. The ACEOI is promulgated at the MAGTF level and is applicable to subordinate commands.

B

ballistic missile. Any missile that does not rely upon aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory when thrust is terminated.

bandit. Aircraft identified as a threat.

barrage fire. Fire which is designed to fill a volume of space or area rather than aimed specifically at a given target.

barrage jamming. Simultaneous electronic jamming over a broad band of frequencies.

battalion landing team (BLT). In an amphibious operation, an infantry battalion normally reinforced by necessary combat and service elements; the basic unit for planning an assault landing.

battery center. A point on the ground the coordinates of which are used as a reference indicating the location of the battery in the production of firing data.

battery left (right). A method of firing in which weapons are discharged from the left (right), one after the other, at 5-second intervals.

battlefield illumination. The lighting of the battle area by artificial light either visible or invisible to the naked eye.

battlefield surveillance. Systematic observation of the battle area for the purpose of providing timely information and combat intelligence.

beach head. A designated area on the hostile shore that, when seized and held, ensures the continuous landing of troops and material and provides maneuver space requisite for subsequent projected operations ashore. It is the physical objective of an amphibious operation.

beam rider. missile guided by an electronic beam.

beaten zone. The area on the ground upon which the cone of fire falls.

break phase. Indicative of relative altitudes and velocities of separate aircraft. To break phase is to maneuver with an attitude and velocity different from that of wingman or adversary. This technique is extremely important for both offensive and defensive actions.

break plane. Referencing the vertical and horizontal planes of motion available to all aircraft. To break plane is to maneuver in vertical or horizontal planes other than those occupied by another aircraft. This technique is extremely important for both offensive and defensive actions.

break turn. An immediate maneuver using maximum performance turns to counter hostile airborne or ground-based weapon systems in position to fire. Break turns are normally employed to defend against surprise encounters.

blood chit. A small cloth chart depicting an American flag and a statement in several languages to the effect that anyone assisting the bearer to safety will be rewarded.

boat diagram. In the assault phase of an amphibious operation, a diagram showing the positions of individuals and equipment in each boat.

bogey. An air contact which is unidentified but assumed to be enemy.

bomb damage assessment (BDA). The determination of the effect of all air attacks on a given target.

bombing height. In air operations, the height above ground level at which the aircraft is flying at the moment of ordnance release. Bombing heights are classified as follows:

very low:	below 100 feet
low:	fm 100 to 2,000 feet
medium:	fm 2,000 to 10,000 feet
high:	fm 10,000 to 50,000 feet
very high:	50,000 feet and above

boundary. In land warfare, a line by which areas of responsibility between adjacent units/formations are defined.

bracketing. A method of adjusting fire in which a bracket is established by obtaining an over and short along the spotting line and then successively splitting

the bracket in half until a target hit or desired bracket is obtained.

brevity code. A code that provides no security but which has as its sole purpose the shortening of messages rather than the concealment of their content.

bright source protection. Protective feature associated with second and third generation I^2 devices; protects the device's microchannel plate by limiting voltage emitting from the photocathode.

C

call fire. Fire delivered on a specific target in response to a request from the supported unit.

call for fire. A request for fire containing data necessary for obtaining the required fire on a target.

campaign plan. A plan for a series of related military operations aimed to accomplish a common objective, normally within a given time and space.

cancel. In artillery and naval gunfire support, the term cancel, when coupled with a previous order other than an order for quantity or type of ammunition, rescinds that order.

cannot observe. A type of fire control that indicates that the observer or spotter will be unable to adjust fire, but believes a target exists at the given location and is of sufficient importance to justify firing upon it without adjustment or observation.

C-day. The unnamed day on which a deployment operation commences or is to commence.

celestial guidance. The guidance of a missile or other vehicle by reference to celestial bodies.

centralized control. In air defense, the control mode whereby a higher echelon makes direct target assignments to fire units.

checkpoint. Geographical location on land or water above which the position of an aircraft in flight may be determined by observation or by electronic means (JCS Pub 1-02).

clock code position. The position of a target in relation to an aircraft or ship with dead-ahead position considered as 12 o'clock.

chaff. Radar confusion reflectors, which consist of thin, narrow metallic strips of various lengths and frequency responses, are used to reflect echoes for confusion purposes.

charge. The amount of propellant required for a fixed, semifixed, or separate loading projectile, round or shell. It may also refer to the quantity of explosive filling contained in a bomb, mine, or the like

check firing. A command to cause a temporary halt in firing.

circular error probable (CEP). An indicator of the delivery accuracy of a weapon system, used as a factor in determining probable damage to a target. It is the radius of a circle within which half of the missiles/projectiles are expected to fall.

climb to cope. Refers to measures directed at regaining reaction time automatically lost/reduced by operating at low-level flight altitudes.

close air support (CAS). Air action against hostile targets that are in close proximity to friendly forces and that require detailed integration of each air mission with the fire and movement of those forces.

close supporting fire. Fire placed on enemy troops, weapons, or positions that, because of their proximity, present the most immediate and serious threat to the supported unit.

code word. A word that has been assigned a classification and a classified meaning to safeguard intentions and information regarding a classified plan or operation (JCS Pub 1-02).

collection plan. A plan for collecting information from all available sources to meet intelligence requirements and for transforming those requirements into orders and requests to appropriate agencies.

collocation. The physical placement of two or more detachments, units, organizations, or facilities at a specifically defined location.

combat air patrol (CAP). An aircraft patrol provided over an objective area, over the force protected, over the critical area of a combat zone, or over an air defense area for the purpose of intercepting and destroying hostile aircraft before they reach their target.

combat information center (CIC). The agency in a ship or aircraft manned and equipped to collect, display, evaluate, and disseminate tactical information for the use of the embarked flag officer, commanding officer, and certain control agencies.

combat surveillance. A continuous, all-weather, day-and-night, systematic watch over the battle area to provide timely information for tactical combat operations.

commander, amphibious task force (CATF). The Navy officer designated in the initiating directive as commander of the amphibious task force.

commander, landing force (CLF). The officer designated in the initiating directive to command the landing force.

command guidance. A guidance system wherein intelligence transmitted to the missile from an outside source causes the missile to traverse a directed flightpath.

communication-electronic operation instructions(CEOI). An instruction containing details on call-sign assignments, frequency assignments, codes and ciphers, and authentication tables and their use. Designed to complement information contained in operational unit communication SOP's or Annex K to the operations order. The most common version of CEOI used by the Marine Corps is the automated communication-electronic operating instructions (ACEOI), produced by NASA.

communication intelligence (COMINT). Technical and intelligence information derived from foreign communications by other than the in tended recipients.

concept of operations. A verbal or graphic statement, in broad outline, of a commander's assumptions or intent regarding an operation or series of operations.

contact point (CP). In air operations, the position at which a mission leader makes radio contact with an air control agency.

contact report. A report indicating any detection for the enemy.

continue. In close air support, the terminal controller's instruction meaning that the attack aircraft appears to be tracking the correct target and is cleared to continue the run. This is not a clearance to release ordnance.

continuous fire. Fire conducted at a normal rate without interruption for application of adjustment corrections or for other causes. In field artillery and naval gunfire support, loading and firing at a specified rate, or as rapidly as possible, consistent with accuracy within the prescribed rate of fire for the weapon. Firing will continue until terminated by the command "END OF MISSION" or temporarily suspended by the command "CEASE LOADING" or "CHECK FIRING."

continuous illumination fire. A type of fire in which illuminating projectiles are fired at specified time intervals to provide uninterrupted lighting on the target or specified area.

control of electromagnetic radiation. An operational plan to minimize the use of electromagnetic radiation in the event of attack or imminent threat thereof as an aid to the navigation of hostile aircraft, guided missiles, or other devices.

control point. A position marked by a buoy, boat, aircraft, electronic device, conspicuous terrain feature, or other identifiable object that is given a name or number and used as an aid to navigation or control of ships, boats, or aircraft.

converge. In artillery and naval gunfire support, a command or request used in a call for fire to indicate that the observer or spotter desires the planes of fire to intersect at a point.

converged sheaf. The lateral distribution of fire of two or more pieces so that the planes of fire intersect at a given point.

convoy escort. A naval ship or aircraft in company with a convoy and responsible for its protection.

coordinated fire line (CFL). A line beyond which conventional surface fire support means (mortars, artillery, and NGFS) may fire at any time within the zone of the establishing headquarters without additional coordination.

coordinated illumination fire. A type of fire in which the firing of illuminating and high explosive projectiles are coordinated to provide illumination of the target and surrounding area only at the time required for spotting and adjusting the high explosive fire.

correction. In fire control, any change in firing data to bring the mean point of impact or burst closer to the target. A communication proword to indicate that an error in data has been announced and that corrected data will follow.

covering fire. Fire used to protect troops when they are within range of enemy small arms. In amphibious usage, fire delivered prior to the landing to cover preparatory operations such as underwater demolition or minesweeping.

critical node. An element, position, or communication entity whose disruption or destruction immediately degrades the ability of a force to command, control, or effectively conduct combat operations.

cross tell. The transfer of information between facilities at the same operational level.

cryogenic liquid. Liquefied gas at very low temperature, such as liquid oxygen, nitrogen, argon.

D

danger. Information in a call for fire to indicate that friendly forces are within 600 to 1,500 meters of the target for artillery or 750 to 2,000 yards for naval gunfire support (NGFS).

danger close. In artillery and naval gunfire support, information in a call for fire to indicate that friendly forces are within a specified distance of the target.

data mile. A standard unit of distance — 6,000 feet.

dazzle. Temporary loss of vision or a temporary reduction in visual acuity.

D-day. The unnamed day on which a particular operation commences or is to commence.

decentralized control. In air defense, the normal mode whereby a higher echelon monitors unit actions, making direct target assignments to units only when necessary to ensure proper fire distribution or to prevent engagement of friendly aircraft.

dedicated battery. A field artillery cannon battery whose total firepower is immediately available to suppress enemy direct fire weapons that threaten a designated maneuver unit.

deep supporting fire. Fire directed on objectives not in the immediate vicinity of our forces for neutralizing and destroying enemy reserves and weapons and interfering with enemy command, supply, communications, and observations.

defensive fire. Fire delivered by supporting units to assist and protect a unit engaged in a defensive action.

Delta T. The difference of an object's temperature to that of the object's background or surroundings.

description of target. In artillery and naval gunfire support, an element in the call for fire in which the observer or spotter describes the installation personnel, equipment, or activity to be taken under fire.

destroyed. A condition of a target so damaged that it cannot function as intended nor be restored to a usable condition.

destruction area. An area in which it is planned to destroy or defeat the enemy airborne threat (JCS Pub 1-02).

destruction fire. Fire delivered for the sole purpose of destroying material objects.

destructive fire mission. In artillery, fire delivered for the purpose of destroying a point target.

deviation. The distance by which a point of impact or burst misses the target.

diopter. A measure of the refractive (light bending) power of a lens.

direct air support center (DASC). A subordinate operational component of a tactical air control system designed for control and direction of close air support and other tactical air support operations. This component is normally collocated with the senior fire support coordination elements.

direct air support center (airborne) (DASC(A)). An airborne aircraft equipped with the necessary staff personnel, communications, and operation facilities to function as a DASC.

direct damage assessment. A direct examination of an actual strike area by air observation, air photography, or by direct observation.

direct fire. Gunfire delivered on a target, using the target itself as a point of aim for either the gun or the director.

direction. In artillery and naval gunfire support, a term used by a spotter or observer in a call for fire to indicate the bearing of the spotting line.

direct support (DS). A mission requiring a force to support another specific force and authorizing it to answer directly the supported force's request for assistance.

direct supporting fire. Fire delivered in support of part of a force, as opposed to general support fire that is delivered in support of the force as a whole.

dispersion error. The distance from the point of impact or burst of a round to the mean point of impact or burst.

dispersion pattern. The distribution of a series of rounds fired from one weapon or group of weapons under conditions as nearly identical as possible to the points of bursts or impact being dispersed about a point called the MEAN POINT OF IMPACT.

distributed fire. Fire so dispersed as to engage most effectively an area target.

divert. To change the target, mission, or destination of an airborne flight.

division artillery. Artillery that is permanently an integral part of a division. For tactical purposes, all artillery placed under the command of a division commander is considered division artillery.

door bundle. A bundle for manual ejection in flight normally followed by parachutists.

Doppler effect. The phenomenon evidenced by the change in the observed frequency of a sound or radio wave caused by a time rate of change in the effective length of the path of travel between the course and the point of observation.

Doppler radar. A radar system that differentiates between fixed and moving targets by detecting the apparent change in frequency of the reflected wave caused by motion of target or the observer (JCS Pub 1-02).

doubtful. In artillery and naval gunfire support, a term used by an observer or spotter to indicate that he was unable to determine the difference in range between the target and a round or rounds.

down. In artillery and naval gunfire support:

1. A term used in a call for fire to indicate that the target is at a lower altitude than the reference point used in identifying the target.

2. A correction used by an observer or a spotter in time fire to indicate that a decrease in height of burst is required.

drop. In artillery and naval gunfire support, a correction used by an observer or a spotter to indicate that a decrease in range along a spotting line is desired.

drop zone (DZ). A specified area upon which airborne troops, equipment, or supplies are airdropped.

E

E-day. The day on which a NATO exercise commences.

effective damage. That damage necessary to render a target element inoperative, unserviceable, nonproductive, or uninhabitable.

effective range. The maximum distance at which a weapon may be expected to fire accurately to inflict casualties or damage.

electroluminescent. A term used to refer to a light emission that occurs in a material (phosphor) as a result of a dynamically changing electrostatic field.

electronic counter-countermeasures (ECCM). That division of electronic warfare involving actions taken to ensure friendly effective use of the electromagnetic spectrum despite the enemy's use of electronic warfare.

electronic countermeasures (ECM). That division of electronic warfare involving actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum.

electronic warfare support measures. That division of electronic warfare involving actions taken under direct control of an operational commander to search for, intercept, identify, and locate sources of radiated electromagnetic energy for the purpose of immediate threat recognition. Thus, electronic warfare support measures provide a source of information required for immediate decisions involving electronic countermeasures (ECM), electronic counter-countermeasures (ECCM), avoidance, targeting, and other tactical employment of forces. Also called ESM. Electronic warfare support measures data can be used to produce signal intelligence (SIGINT), both communication intelligence (COMINT) and electronic intelligence (ELINT).

electronic intelligence (ELINT). Technical and intelligence information derived from foreign noncommunication electromagnetic radiation emanating from other than nuclear detonations or radioactive sources.

electronic warfare (EW). Military action involving the use of electromagnetic energy to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum and action that retains friendly use of the same.

electro-optical intelligence (ELECTROOPINT). Intelligence information other than signal intelligence derived from the optical monitoring of the electromagnetic spectrum from ultraviolet (0.01 micrometers) through far infrared (1,000 micrometers).

electro-optics (EO). The interaction between optics and electronics leading to the transformation of electrical energy into light, or vice versa, with the use of an optical device.

elevation. The vertical distance of a point or level, on, or affixed to, the surface of the Earth measured from mean sea level.

emergency mission. Mission involves safety of U.S. or other friendly lives or requires immediate transport of vital supplies or equipment or urgently required resupply ammunition or medical supplies.

emergency priority. A category of immediate mission request that takes precedence over all other priorities.

emission control (EMCON). Selected control of emitted electromagnetic or acoustic energy to minimize its detection by enemy sensors or to improve the performance of installed friendly sensors.

end of mission. In artillery and naval gunfire support, an order given to terminate firing on a specific target.

engaged. The flight members being aggressed by enemy aircraft. An engaged aircrew will normally become the tactical leader of its section.

escort flight leader. An experienced aviator in command of the escort aircraft taking part in a helicopterborne mission.

essential elements of friendly information (EEI). Key questions about friendly intentions and military capabilities likely to be asked by opposing planners and decision-makers in competitive circumstances.

essential elements of information (EEI). The critical items of information regarding the enemy and the environment needed by the commander by a particular time to relate with other available information and intelligence in order to assist in reaching a logical decision.

exfiltration. The removal of personnel or units from areas under enemy control.

expeditionary force. An armed force organized to accomplish a specific objective in a foreign country.

extension. Aircraft maneuver used to increase separation from a target. Usually employed following an attack, an extension is often executed at low altitude to rapidly escape an adversary's weapon parameters.

extraction zone. A specified drop zone used for the delivery of supplies and/or equipment by means of an extraction technique from an aircraft flying very close to the ground.

F

field artillery. Equipment, supplies, ammunition, and personnel involved in the use of cannon, rocket, or surface-to-surface missile launchers. Field artillery cannons are classified according to caliber as:

light:	120 mm and less
medium:	121 to 160 mm
heavy:	161 to 210 mm
very heavy:	greater than 210 mm

field artillery observer. A person who watches the effects of artillery fire, adjusts the center of impact of that fire onto a target, and reports the results to the firing agency.

field of fire. That area which a weapon or a group of weapons may cover effectively with fire from a given position.

field of view (FOV). The total solid angle available to the gunner when looking through the gunsight.

fighter engagement zone (FEZ). The geographic, three dimensional subdivision of the destruction area where fighters have primary responsibility for the destruction of the airborne threat. FEZs may be designated within the air intercept zone (AIZ).

fire capabilities chart. A chart, usually in the form of an overlay, showing the areas that can be reached by the fire of the bulk of the weapons of a unit.

fire control. The control of all operations in connection with the application of fire on a target.

fire control radar. Radar used to provide target information inputs to a weapon fire control system.

fire coordination area (FCA). An area with specified restraints into which fire in excess of those restraints will not be delivered without approval of the authority establishing the restraints.

fire direction center (FDC). That element of a command post, consisting of gunnery and communications personnel and equipment, by means of which the commander exercises fire direction and/or fire control. The fire direction center receives target intelligence and requests for fire and translates them into appropriate fire direction.

fire for effect (FFE). Fire that is delivered after the mean point of impact or burst is within the desired distance of the target or adjusting/ranging point. Term in a call for fire to indicate the adjustment/ranging is satisfactory and fire for effect is desired.

fire mission. Specific assignment given to a fire unit as part of a definite plan. Order used to alert the weapon/battery area and indicate that the message following is a call for fire.

fire plan. A tactical plan for using the weapons of a unit or formation so that their fire will be coordinated.

fire support area (FSA). An appropriate maneuver area assigned to fire support ships from which to deliver gunfire support of an amphibious operation.

fire support coordination. The planning and executing of fire so that targets are adequately covered by a suitable weapon or group of weapons.

fire support coordination center (FSCC). A single location in which are centralized communication facilities and personnel incident to the coordination of all forms of fire support.

fire support coordination line (FSCL). A line established by the appropriate ground commander to ensure coordination of fire not under his control, but which may affect current tactical operations. It is used to coordinate fires of air, ground, or sea weapon systems using any type of ammunition against surface targets. It should follow well-defined terrain features. Support elements may attack targets forward of the fire support coordination line, without prior coordination with the ground force command, provided the attack will not produce adverse surface effects on or to the rear of the line.

fire support group. A temporary grouping of ships under a single commander charged with supporting troop operations ashore by naval gunfire. A fire support group may be further subdivided into fire support units and fire support elements.

fire support station (FSS). An exact location at sea within a fire support area from which a fire support ship delivers fire.

firing chart. Map, photo map, or grid sheet showing the relative horizontal and vertical positions of batteries, base points, base point lines, checkpoints, targets, and other details needed in preparing firing data.

first salvo at. In naval gunfire support, a portion of a ship's message to an observer or spotter to indicate that because of proximity to troops, the ship will not fire at the target but offset the first salvo a specific distance from the target.

flash blindness. Impairment of vision resulting from an intense flash of light. It includes temporary or permanent loss of visual functions and may be associated with retinal burns.

flux. The rate of transfer of energy.

focal plane. The plane, perpendicular to the optical axis of the lens, in which images of points in the object field or the lens are focused.

foot-candle. A measure of illuminance; specifically, the illuminance of a surface upon which one lumen is falling per square foot.

foot-lambert. A measure of luminance; specifically, the luminance of a surface that is receiving an illuminance of one foot-candle.

force list. A total list of forces required by an operation plan, including assigned forces, augmentation forces, and other forces to be employed in support of the plan.

foreign instrumentation signal intelligence (FISINT). Intelligence information derived from electromagnetic emissions associated with the testing and operational deployment of foreign aerospace, surface, and subsurface systems.

forward air controller (FAC). An officer (NA/NFO) member of the TACP who, from a forward ground position or in the air, controls aircraft engaged in close air support of ground troops.

forward air controller (airborne) (FAC(A)). An NA/NFO/NAO specifically trained and designated to exercise control, from the air, of aircraft engaged in

close air support of ground troops. The FAC(A) is an airborne extention of the TACP or ground commander. He can provide terminal control for CAS aircraft alone or he can assist the FAC.

forward arming and refueling point (FARP). A temporary facility, organized, equipped, and deployed by an aviation commander, and normally located in the main battle area closer to the area of operation than the aviation unit's combat service area to provide fuel and ammunition necessary for the employment of aviation maneuver units in combat.

forward edge of the battle area (FEBA). The foremost limits of a series of areas in which ground combat units are deployed, excluding the areas in which the covering or screening forces are operating, designated to coordinate fire support, the positioning of forces, or the maneuver of units.

forward line of own troops (FLOT). A line that indicates the most forward positions of friendly forces in any kind of military operation at a specific time.

forward looking infrared (FLIR). A system used to detect heat differential between objects and display them visually.

forward observer (FO). An observer operating with front line troops and trained to adjust ground or naval gunfire and pass back battlefield information.

four-round illumination diamond. A method of distributing the fire of illumination shells that, by a combination of lateral spread and range spread, provides illumination of a large area.

fragmentary order (FRAG). An abbreviated form of an operation order, usually issued on a day-to-day basis, that eliminates the need for restating information contained in a basic operation order.

free fall. A parachute maneuver in which the parachute is manually activated at the discretion of the jumper or automatically at a preset altitude.

free-fire area (FFA). A specific, designated area into which any fire support means may deliver fires against known or suspected targets without any coordination between the force requesting and/or delivering the fires and the agency that established the FFA.

free rocket. A rocket not subject to guidance or control in flight.

fresh target. A request or command sent by the observer or spotter to the firing ship to indicate that fire will be shifted from the original target to a new target by spots (corrections) applied to the computer solution being generated.

G

general support (GS). That support that is given to the supported force as a whole and not to any particular subdivision thereof.

general support artillery. Artillery that executes the fire directed by the commander of the unit to which it organically belongs or is attached.

general support reinforcing (GSR). A tactical artillery mission. General support-reinforcing artillery has the mission of supporting the force as a whole and of providing reinforcing fires for another artillery unit.

graze. In artillery and naval gunfire support, a spotting or an observation by a spotter or an observer to indicate that all bursts occurred on impact.

grazing fire. Fire approximately parallel to the ground where the center of the cone of fire does not rise above one meter from the ground.

ground alert. That status in which aircraft on the ground/deck are fully serviced and armed with combat crews in readiness to take off within a specified short period of time after receipt of a mission order.

ground nadir. The point on the ground vertically beneath the perspective center of the camera lens.

group of targets. Two or more targets on which fire is desired simultaneously. A group of targets is designated by a letter/number combination or nickname.

guided missile. An unmanned vehicle moving above the surface of the Earth whose trajectory or flightpath is capable of being altered by an external or internal mechanism.

gun. A cannon with relatively long barrel, operating with relatively low angle of fire, and having a high muzzle velocity. A cannon with tube length 30 calibers or more.

gun direction. The distribution and direction of the gunfire of a ship.

gun target line (GTL). An imaginary straight line from the gun(s) to the target.

H

hack. The command used by the terminal controller to initiate the start of a previously briefed period of time at the conclusion of which a given event is to occur.

hang fire. An undesired delay in the functioning of a fire system.

harassing fire. Fire designated to disturb the rest of the enemy troops, to curtail movement, and, by threat of losses, to lower morale.

height. The vertical distance of an object, point, or level above the ground or other established reference plane. Height may be indicated as follows:

very low:	Less than 500 ft.
low:	500 to 2,000 ft. AGL
medium:	2,000 to 25,000 ft.
high:	25,000 to 50,000 ft.
very high:	More than 50,000 ft.

height of burst (HOB). The vertical distance from the Earth's surface or target to the point of burst.

helicopter approach route. The track or series of tracks along which helicopters move to a specific landing site or landing zone.

helicopter assault force. A task organization combining helicopters, supporting units, and helicopterborne troop units for use in helicopterborne assault operations.

helicopter breakup point. A control point at which helicopters returning from a landing zone break formation and are released to return to base or are dispatched for other employment.

helicopter coordinator (airborne) (HC(A)). An experienced aviator operating from a command and control aircraft for the purpose of direct airborne coordination and control of helicopterborne assaults. He is responsible for the control of all helicopters and assigned fixed-wing aircraft participating in and supporting a helicopterborne landing. If employed in conjunction with the TAC(A), he is an agent of the TAC(A) and will be responsible for the control of the helicopters only.

helicopter direction center (HDC). In amphi-bious operations, the primary direct control agency for the helicopter group/unit commander operating under the overall control of the tactical air control center.

helicopter drop point. A designated point within a landing zone where helicopters are unable to land because of the terrain, but in which they can discharge cargo or troops while hovering.

helicopter lane. A safety air corridor in which helicopters fly to or from their destination during helicopter operations.

helicopter landing site. A designated subdivision of a helicopter landing zone in which a single flight or wave of assault helicopters land to embark or disembark troops and/or cargo.

helicopter landing zone (HLZ). A specified ground area for landing assault helicopters to embark or disembark troops and/or cargo. A landing zone may contain one or more landing sites.

helicopter retirement route. The track or series of tracks along which helicopters move from a specific landing site or landing zone.

helicopter support team (HST). A task organization formed and equipped for employment in a landing zone to facilitate the landing and movement of helicopterborne troops, equipment and supplies, and to evacuate selected casualties and prisoners of war.

helicopter team. The combat equipped troops lifted in one helicopter at one time.

helicopterborne unit commander (HUC). The ground officer who has been designated to be the commander of the helicopterborne force and who is charged with the accomplishment of its ground mission.

H-hour. The specific hour on D-day at which a particular operation commences. The operation may be the commencement of hostilities; the hour at which an operation plan is executed or to be executed (as distinguished from the hour the order to execute is issued); the hour that the operation phase is implemented, either by land, parachute, or amphibious assault, air or naval bombardment. The highest command or headquarters coordinating the planning will specify the exact meaning of H-hour within the aforementioned definition. Normally, the letter "H" will be the only one used to denote the above. However, when several operations or phases of an operation are being conducted in the same area on D-day, and

confusion may arise through the use of the same hour designation for two or more of them, any letter of the alphabet may be used except A, C, D, E, J, M, or others that may be reserved for exclusive use (JCS Pub 1-02).

high angle. In artillery and naval gunfire support, an order or request to obtain high angle fire.

high angle fire. Fire delivered at angles of elevation greater than the elevation that corresponds to the maximum range of the gun and ammunition concerned; fire, the range of which decreases as the angle of elevation is increased.

holding point. A geographically or electronically defined location used in stationing aircraft in flight in a predetermined pattern in accordance with air traffic control clearance.

homing guidance. A system by which a missile steers itself toward a target by means of a self-contained mechanism that is activated by some distinguishing characteristics of the target.

howitzer. A cannon that combines certain characteristics of guns and mortars. The howitzer delivers projectiles with medium velocities, either by low or high trajectories.

human intelligence (HUMINT). A category of intelligence derived from information collected and provided by human sources.

hydrographic reconnaissance. Reconnaissance of an area of water to determine depths, beach gradients, the nature of the bottom, and the location of coral reefs, rocks, shoals, and man-made obstacles.

hyperopia. Commonly called farsightedness; the optical error in which an image has not yet come to a point of focus when it reaches the retina.

I

identification friend or foe (IFF). A system using electromagnetic transmissions to which equipment carried by friendly forces automatically responds (for example, by emitting pulses), thereby distinguishing them from enemy forces.

illuminance. The amount, ratio, or density of light incident upon a surface.

image degradation. The reduction of the inherent optimum potential of individual sensor systems caused by error in sensor operations, processing procedures, or incorrect film handling.

image format. Actual size of negative, scope, or other medium on which image is produced.

image-intensifier (I^2). An electron device that reproduces on its fluorescent screen an image of the radiation pattern focused on its photosensitive surface.

imagery. Collectively, the representations of objects reproduced electronically or by optical means on film, electronic display devices, or other media.

imagery intelligence (IMINT). Intelligence information derived from the exploitation of collection by visual photography, infrared sensors, lasers, electro-optics and radar sensors such as synthetic aperture radar wherein imagery of objects is reproduced optically or electronically on film, electronic display devices, or other media.

immediate air support. Air support to meet specific requests that arise during the course of a battle and which by their nature cannot be planned in advance.

immediate suppression. An artillery fire mission warning order indicating that the maneuver force is taking fire and urgently needs fire support.

impact area. An area having designated boundaries within the limits of which all ordnance will detonate or impact.

improved conventional munitions (ICM). Munitions characterized by the delivery of two or more antipersonnel or antimateriel and/or antiarmor submunitions by an artillery warhead or projectile.

incandescent. Refers to a source that emits light based on thermal excitation resulting in a very broad spectrum that is dependent primarily on the temperature of the filament.

indirect fire. Fire delivered on a target that is not itself used as a point of aim for the weapons or the director.

indirect laying. Aiming a gun either by sighting at a fixed object, called the aiming point, instead of the target or by using a means of pointing other than a sight, such as a gun director, when the target cannot be seen from the gun position.

inertial guidance. A guidance system designed to project a missile over a predetermined path, wherein the path of the missile is adjusted after launching by devices wholly within the missile and independent of

outside information. The system measures and converts accelerations experienced to distance traveled in a certain direction.

infiltration. A technique and process in which a force moves as individuals or small groups over, through, or around enemy positions without detection.

infrared imagery. That imagery produced as a result of sensing electromagnetic radiations emitted or reflected from a given target surface in the infrared position of the electromagnetic spectrum (approximately 0.72 to 1,000 microns).

infrared radiation. Radiation emitted or reflected in the infrared portion of the electromagnetic spectrum.

infrared signature (IR). The infrared signature determined by the sum of all heat sources (mechanical, electrical, and solar), such as engine exhaust, gearboxes, reflection from windows and wind screens, and reflective paint and lights.

initial point (IP). A well-defined point, easily distinguishable visually and/or electronically, used as a starting point for the run to the target.

insecure area. In helicopter operations, an area in which helicopters may be subject to hostile firing during the approach, landing, takeoff, or departure phase; fire has been received within the last 72 hours in the zone.

intelligence report (INTREP). A specific report of information, usually on a single item, made at any level of command in tactical operations and disseminated as rapidly as possible in keeping with the timeliness of the information.

intelligence requirement. Any subject, general or specific, upon which there is a need for the collection of information or the production of intelligence.

interdict. To prevent or hinder, by any means, enemy use of an area or route.

interdiction. An action to divert, disrupt, delay or destroy the enemy's surface military potential before it can be used effectively against friendly forces.

interdiction fire. Fire placed on an area or point to prevent the enemy from using the area or point.

intermittent illumination. A type of fire in which illuminating projectiles are fired at irregular intervals.

intervalometer. An electrical device used in releasing/firing weapons at a constant predetermined time interval between releases.

irradiance. The density of radition power incident on a surface.

J

jinking. Continuous random change of heading and altitude along a base course.

joint tactical air reconnaissance/surveillance mission report. A preliminary report of information from tactical reconnaissance aircrews rendered by designated debriefing personnel immediately after landing and dispatched prior to compilation of the initial photo interpretation report (IPIR).

joint target list. A consolidated list of selected targets considered to have military significance in the joint operations area.

K

K-day. The basic date for the introduction of a convoy system on any particular convoy lane.

"KNOCK IT OFF." A command used to immediately cease all ACM training and proceed as briefed or return to base.

L

land control operations. The employment of ground forces supported by naval and air forces, as appropriate, to achieve military objectives in vital land areas.

landing area. That part of the objective area where the landing operations of an amphibious force are conducted. It includes the beach, the approaches to the beach, the transport areas, the fire support areas, the air occupied by close supporting aircraft, and the land included in the advance inland to the initial objective.

landing beach. That portion of a shoreline usually required for the landing of a battalion landing team.

landing diagram. A graphic means of illustrating the plan for the ship-to-shore movement.

landing force. A task organization of troop units, aviation and ground, assigned to an amphibious assault. It is the highest troop echelon in the amphibious operation.

landing point (LP). A point within a landing site where one helicopter or vertical takeoff and landing aircraft can land.

landing schedule. In an amphibious operation, a schedule that shows the beach, hour, and priorities of landing of assault units and that coordinates the movement of landing craft from the transports to the beach in order to execute the scheme of maneuver ashore.

landing site (LS). A site within a landing zone containing one or more landing points.

landing zone (LZ). Any specified zone used for the landing of aircraft.

large-scale map. A map having a scale of 1:75,000 or larger.

large spread. A report by an observer or a spotter to the ship to indicate that the distance between the bursts of a salvo is excessive.

laser designator (LD). A device that emits a beam of laser energy that is used to mark a specific place or object.

laser guidance unit (LGU). A device that incorporates a laser seeker to provide guidance commands to the control system of a missile, projectile, or bomb.

laser-guided weapon (LGW). A weapon that utilizes a seeker to detect laser energy reflected from a laser-marked/designated target and through signal processing provides guidance commands to a control system that guides the weapon to the point from which the laser energy is being reflected.

laser illuminator. A device for enhancing the illumination in a zone of action by irradiating with a laser beam.

laser intelligence (LASINT). Technical and intelligence information derived from laser systems; a subcategory of electro-optical intelligence.

laser pulse duration. The time during which the laser output pulse power remains continuously above half its maximum value.

laser range finder. A device that uses laser energy for determining the distance from the device to a place or object.

laser ranger/designator (LRD). A device using a laser beam to illuminate targets for LGW/LSTs or to provide accurate range information.

laser seeker. A device based on a direction sensitive receiver that detects the energy reflected from a laser designated target and defines the direction of the target relative to the receiver.

laser spot tracker (LST). A device used by attack aircraft to visually display a laser target illumination, thus, obtaining precise target location.

laser target designating system (LTD). A system that is used to direct (aim or point) laser energy at a target. The system consists of a laser designator or laser target marker with its display and control components necessary to acquire the target and direct the beam of laser energy there on.

laser tracker. A device that locks on the reflected energy from a laser-marked/designated target and defines the direction of the target relative to itself.

late. In artillery and naval gunfire support, a report made to the observer or spotter whenever there is a delay in reporting shot by coupling the time in seconds with the report.

lateral spread. A technique used to place the mean point of impact of two or more units 100 meters apart on a line perpendicular to the gun-target line.

laydown bombing. A very low level bombing technique wherein delay fuzes and/or devices are used to allow the attacker to escape the effects of his bomb.

L-hour. The time at which the first helicopter assault wave touches down in the landing zone (FMFRP 0-18).

line of departure. A line designated to coordinate the departure of attack or scouting elements.

line of impact. A line tangent to the trajectory at the point of impact or burst.

lines of communications. All the routes (land, water, and air) that connect an operating military force with a base of operations and along which supplies and military forces move.

list of targets. A tabulation of confirmed or suspect targets maintained by any echelon for information and fire support planning puposes.

loading point. A point where one aircraft can be loaded or unloaded.

loading site. An area containing a number of loading points.

lock-on. Signifies that a tracking or target-seeking system is continuously and automatically tracking a target in one or more coordinates (e.g., range, bearing, elevation).

loft bombing. A method of bombing in which the delivery plane approaches the target at a very low altitude, makes a definite pullup at a given point, releases bomb at predetermined point during the pullup, and tosses the bomb onto the target.

lost. In artillery and naval gunfire support, a spotting or an observation used by a spotter or an observer to indicate that rounds fired by a gun or mortar were not observed.

low-altitude bombing system (LABS). A system used in jet attack aircraft to permit accurate, automatic weapon release during loft and over-the-shoulder deliveries.

low angle. In artillery and naval gunfire support, an order or request to obtain low-angle fire.

low-angle fire. Fire delivered at angles of elevation below the elevation that corresponds to the maximum range of the gun and ammunition concerned.

low-level flight. Flight along a preplanned route consisting of straight-line route segments between identifiable checkpoints. A constant airspeed is maintained, and altitude is generally steady over each route segment.

LSC. Linear shaped charge.

luminance. The amount of light reflected from a surface.

lux. A measure of illuminance; specifically the illuminance produced from the flux of one lumen against a surface.

M

main armament. The request of the observer or spotter to obtain fire from the largest guns installed on the fire support ship.

mandatory mission. Emergency in nature and involves possible loss of human life or national prestige to the extent that normally unacceptable risks will be taken in its accomplishment.

manpad. This classification covers manportable missile systems intended for the protection of forward area point targets as an attrition weapon against low-flying aircraft. A system fulfilling this role is the SA-14/16 or U.S. Stinger missile.

Marine air command and control system (MACCS). A U.S. Marine Corps tactical air command and control system that provides the tactical air commander with the means to command, coordinate, and control all air operations within an assigned sector and to coordinate air operations with other services. It is composed of command and control agencies with communications equipment that incorporates a capability from manual through semiactive control.

Marine air control squadron (MACS). The component of the Marine air control group that provides and operates ground facilities for the detection and interception of hostile aircraft and for the navigational direction of friendly aircraft in the conduct of support missions.

Marine air-ground task force (MAGTF). A Marine air-ground task force is a task organization of Marine forces under a single command and structured to accomplish a specific mission. The Marine air-ground task force components will normally include command, ground combat, aviation combat, and combat service support elements.

Marine air support squadron (MASS). The component of the Marine air control group that provides and operates facilities for the control of support aircraft operating in direct support of ground forces.

Marine expeditionary brigade (MEB). A task organization that is normally built around a regimental landing team, a provisional Marine aircraft group, and a logistic support group. It is capable of conducting amphibious assault operations of a limited scope.

Marine expeditionary force (MEF). The largest of the marine air-ground task forces; it is normally built around a division/wing team, but can include several divisions and aircraft wings, together with an appropriate combat service support organization. It is capable of conducting a wide range of amphibious assault operations and sustained operations ashore.

Marine expeditionary unit (MEU). A task organization that is normally built around a battalion landing team, composite squadron, and logistic support unit. It fulfills routine forward afloat deployment requirements, provides an immediate reaction capability for crisis situations, and is capable of relatively limited combat operations.

mark. In artillery and naval gunfire support:

1. A call for fire on a specified location to orient the observer or spotter or to indicate targets

2. A report made by the observer or spotter in firing illumination shells to indicate the instant of optimum light on the target. In close air support and air interdiction, an air control agency's term utilized to indicate the point of weapon release.

marking fire. Fire placed on a target for the purpose of identification.

marking panel. A sheet of material displayed for visual communications usually between friendly units.

maximum effective range. The maximum distance at which a weapon may be expected to be accurate and achieve the desired results.

maximum ordinate (MAXORD). In artillery and naval gunfire support:

1. The highest point along the trajectory of a projectile

2. The difference in altitude (vertical interval) between the origin and the summit of the trajectory of a projectile.

maximum range. The greatest distance a weapon can fire without consideration of dispersion.

M-day. The term used to designate the day on which mobilization is to begin.

meaconing. A system of receiving radio beacon signals and rebroadcasting them on the same frequency to confuse navigation.

mean point of impact (MPI). The point whose coordinates are the arithmetic means of the coordinates of the separate points of impact/burst of a finite number of projectiles fired or released at the same aiming point under a given set of conditions.

medium-scale map. A map having a scale larger than 1:600,000 and smaller than 1:75,000.

microchannel plate. A wafer of specially treated microscopic glass tubes designed to multiply electrons passing from the photocathode to the phosphor screen in second- and third-generation I^2 devices.

mil. The unit of angular measurement based on the angle subtended by 1/6,400th of the circumference of a circle. One mil angular measurement will subtend an arc one meter in length at a distance of 1,000 meters. One degree equals 17.45 mils.

military grid reference system. A system that uses a standard-scaled grid square, based on a point of origin on a map projection of the surface of the Earth, in an accurate and consistent manner to permit either position referencing or the computation of direction and distance between grid positions.

minimum range. Least range setting of a gun at which the projectile will clear an obstacle or friendly troops between the gun and the target. The shortest distance to which a gun can fire from a given position.

missile engagement zone (MEZ). The geographic, three-dimensional subdivision of the destruction area where surface-to-air missiles have primary responsibility for destruction of the airborne threat.

mission precedence. A designation assigned to a mission to indicate its priority or urgency of accomplishment.

mixed. In artillery and naval gunfire support, a spotting or an observation by a spotter or an observer to indicate that the rounds fired resulted in a equal number of air and impact bursts.

mixed air. In artillery and naval gunfire support, a spotting or an observation by a spotter or an observer to indicate that the rounds fired resulted in both air and impact bursts with a majority of the bursts being air bursts.

mixed graze. In artillery and naval gunfire support, a spotting or an observation by a spotter or an observer to indicate that the rounds fired resulted in both air and impact bursts with a majority of the bursts being impact bursts.

mortar. A muzzle-loading, indirect fire weapon with either a rifled or smooth bore. It usually has a shorter range than a howitzer, employs a higher angle of fire, and has a tube length of 10 to 20 calibers.

mosaic. An assembly of overlapping photographs that have been matched to form a continuous photographic representation of a portion of the surface of the Earth.

moving target indicator (MTI). A radar presentation that shows only targets that are in motion. Signals from stationary targets are subtracted out of the return signal by the output of a suitable memory circuit.

multispectral imagery. The image of an object obtained simultaneously in a number of discrete spectral bands.

myopia. Commonly called nearsightedness; the optical error in which an object comes to a point of focus before it reaches the retina.

N

nadir. That point on the celestial sphere directly beneath the observer and directly opposite the zenith.

nap-of-the-Earth flight (NOE). Flight as close to the Earth's surface as vegetation or obstacles will permit, while generally following the contours of the Earth.

naval gunfire liaison team. Personnel and equipment required to coordinate and advise ground/landing forces on naval gunfire employment.

naval gunfire operation center. The agency established in a ship to control the execution of plans for the employment of naval gunfire, process requests for naval gunfire support, and to allot ships to forward observers.

naval gunfire spotting team. The unit of a shore fire control party that designates targets; controls commencement, cessation, range, and types of fire; and spots fire on the target.

naval tactical data system (NTDS). A complex of data inputs, user consoles, converters, adapters, and radio terminals interconnected with high-speed general purpose computers and its stored programs. Combat data are collected, processed, and composed into a picture of the overall tactical situation, which enables the force commander to make rapid, accurate evaluations and decisions.

neglect. In artillery and naval gunfire support, a report to the observer or spotter to indicate that the last round(s) was fired with incorrect data and that the round(s) will be fired again using correct data.

neutralization fire. Fire which is delivered to render ineffective or unusable.

neutralize. As pertains to military operations, to render ineffective or unusable.

night vision device. Any device designed to enhance or improve night vision.

node. A location in a mobility system where a movement requirement is originated, processed for onward movement, or terminated.

no-fire area (NFA). A specific, designated area into which no fire support means will deliver fires and into which no effects from their fires will extend unless:

1. The establishing agency requests or temporarily approves such actions, or

2. Self-defense.

no-fire line (NFL). A line short of which artillery or ships do not fire except on request or approval of the supported commander, but beyond which they may fire at any time without danger to friendly troops.

normal charge. Charge employing a standard amount of propellant to fire a gun under ordinary condition as compared with a reduced charge.

number of rounds. In artillery and naval gunfire support, a command or request used to indicate the number of projectiles per tube to be fired on a specified target.

O

oblique air photograph. An air photograph taken with a camera axis directed between the horizontal and vertical planes. Commonly referred to as an oblique:

1. High oblique — one in which the apparent horizon appears

2. Low oblique —one in which the apparent horizon does not appear.

observed fire. Fire for which the point of impact or burst can be seen by an observer. The fire can be controlled and adjusted on the basis of observation.

observer-target distance (OTD). The distance along an imaginary straight line from the spotter or observer to the target.

observer-target line (OTL). An imaginary straight line from the observer or spotter to the target.

observer-target range (OTR). The distance along an imaginary straight line from the observer or spotter to the target.

on call. A term used to signify that a prearranged concentration, air strike, or final protective fire may be called for.

on-call target. In artillery and naval gunfire support, a planned target other than a scheduled target on which fire is delivered when requested.

on-scene commander. The person designated to coordinate the rescue efforts at the rescue site.

on station. In close air support and interdiction, means airborne aircraft are in position to attack targets or to perform the mission designated by control agency.

on-station time. The time an aircraft can remain on station.

O-O line. A line for the coordination of field artillery observation, designated by the artillery commander and dividing primary responsibility for observation between units.

open. Term used in a call for fire to indicate that the spotter or observer desires bursts to be separated by the maximum effective width of the burst of the shell fired.

open sheaf. The lateral distribution of the fire of two or more pieces so that adjoining points of impact or points of burst are separated by the maximum effective width of burst of the type shell being used.

operational environment. A composite of the conditions, circumstances, and influences that affect the employment of military forces and bear on the decisions of the unit commander.

operation order. A directive, usually formal, issued by a commander of subordinate commanders for the purpose of effecting the coordinated execution of an operation.

operation plan. A plan for a single operation or series of connected operations to be carried out simultaneously or in succession. It is usually based upon stated assumptions and is in the form of a directive employed by higher authority to permit subordinate commanders to prepare supporting plans and orders.

operation security (OPSEC). The process of denying adversaries information about friendly capabilities and intentions by identifying, controlling, and protecting indicators associated with planning and conducting military operations and other activities.

orbit point. A geographically or electronically defined location used in stationing aircraft in flight during tactical operations when a predetermined pattern is not established.

order of battle. The identification, strength, command structure, and disposition of the personnel, units, and equipment of any military force.

overlay. A printing or drawing on a transparent or semitransparent medium at the same scale as a map, chart, etc., to show details not appearing or requiring special emphasis on the original.

overshoot. Maneuver that carries an aircraft beyond its intended flightpath. It often occurs when a rear hemisphere attacker unintentionally flies beyond a defender's smaller turn radius.

over-the-shoulder bombing. A special case of loft bombing where the bomb is released past the vertical in order that the bomb may be thrown back to the target.

overt operations. The collection of intelligence openly, without concealment.

P

Pa. Probability of acquisition.

padlock. A term indicating an aircraft or crewmember is dedicated to maintaining visual contact with an enemy aircraft.

panel code. A prearranged code designed for visual communications between friendly units by making use of marking panels.

paradrop. Delivery by parachute of personnel or cargo from aircraft in flight.

parallel sheaf. In artillery and naval gunfire support, a sheaf in which the planes of fire of all pieces are parallel.

passive homing guidance. A system of homing guidance wherein the receiver in the missile utilizes radiation from the target (JCS Pub 1-02).

Pd. Probability of detection.

P-day. That point in time at which the rate of production of an item available for military consumption equals the rate at which the item is required by the armed forces.

photo nadir. The point at which the vertical line through the perspective center of the camera lens intersects the photo plane.

photopic vision. That vision produced as a result of the response of the cones in the retina as the eye achieves a light adapted state (commonly referred to as day vision).

pinpoint target. In artillery and naval gunfire support, a target less than 50 meters in diameter.

Pk. Probability of kill.

planned target. In artillery and naval gunfire support, a target on which fire is prearranged.

point target. A target of such small dimension that it requires the accurate placement of ordnance in order to neutralize or destroy it.

polar coordinates. In artillery and naval gunfire support, the direction, distance, and vertical correction from the observer or spotter position to the target.

polar plot. The method of locating a target or point on the map by means of polar coordinates.

poststrike reconnaissance. Missions undertaken for the purpose of gathering information used to measure results of a strike.

prearranged fire. Fire that is formally planned and executed against targets or target areas of known location.

predicted fire. Fire that is delivered without adjustment.

preparation fire. Fire delivered on a target preparatory to an assault.

preplanned air support. Air support in accordance with a program, planned in advance of operations.

preplanned mission request. A request for an air strike on a target that can be anticipated sufficiently in advance to permit detailed mission coordination and planning.

prestrike reconnaissance. Missions undertaken for the purpose of obtaining complete information about known targets for use by the strike force.

priority MEDEVAC. Evacuation of seriously wounded, injured, or ill personnel who require early hospitalization but whose immediate evacuation is not a matter of life or death.

priority mission. Tactical movement of equipment or personnel whose excessive delay would jeopardize successful mission accomplishment. It includes logistic operations where delays would result in excessive material loss through spoilage or seizure by the enemy.

procedural control. A method of airspace control that relies on a combination of previously agreed upon and promulgated orders and procedures.

pullup point (PUP). The point at which an aircraft must start to climb from a low-level approach in order to gain sufficient height from which to execute the attack or retirement.

pursuit-in-air-intercept. A description of the flightpath of a pursuing aircraft relative to the one being pursued. Pure pursuit occurs when the two aircraft follow the same path in space. Lead pursuit occurs when the pursuing aircraft flies inside the turn radius of the other, while in lag pursuit, he flies to the outside.

Q

quadrant elevation (QE). The angle between the level base of the trajectory (horizontal) and the axis of the bore when laid (maximum and minimum).

R

radar fire. Gunfire aimed at a target that is tracked by radar.

radar intelligence (RADINT). Intelligence information derived from data collected by radar.

radar reconnaissance. Reconnaissance by means of radar to obtain information on enemy activity and to determine the nature of terrain.

radar warning receiver (RWR). A receiver on board an aircraft providing information to the aircrew about radar signals impinging upon the vehicle.

radiance. The density of radiant power reflected from a surface.

radio silence. A condition during which all or certain radio equipment capable of radiation is kept inoperative (JCS Pub 1-02).

reflectance. This is the relationship between illumination reaching a surface and the resulting luminance. A perfectly diffusing and reflecting surface would be one that absorbs no light and scatters the illumination in the manner of a perfectly flat surface. Such a surface would have a reflectance of 100°. If illuminated by 1-foot-c, it would have a luminance of 1-foot-Lambert (fl-L) from all viewing angles. In actual practice, the maximum reflectance achievable for a nearly perfect diffusing surface is about 75 percent.

range spread. The technique used to place the mean point of impact of two or more units 100 meters apart on the gun-target line.

rate of fire. The number of rounds fired per weapon per minute.

ready. The term used to indicate that a weapon is loaded, aimed, and prepared to fire.

reconnaissance (RECON). A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy; or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.

reconnaissance by fire. A method of reconnaissance in which fire is placed on a suspected enemy position to cause the enemy to disclose his presence by movement or return of fire.

record as target. In artillery and naval gunfire support, the order used to denote that the target is to be recorded for future engagement or reference.

recorded. In artillery and naval gunfire support, the response used to indicate that the action taken to record as target has been completed.

reduced charge. Charge employing a reduced amount of propellant to fire a gun at short ranges as compared to a normal charge.

reference line (RL). A convenient and readily identifiable line used by the observer or spotter as the line to which spots will be related.

registration. The adjustment of fire to determine firing data corrections.

registration fire. Fire delivered to obtain accurate data for subsequent effective engagement of targets.

registration point. Terrain feature or other designated point on which fire is adjusted for the purpose of obtaining corrections to firing data.

reinforcing. In artillery usage, tactical mission in which one artillery unit augments the fire of another artillery unit.

remotely piloted vehicle (RPV). An unmanned air vehicle capable of being controlled by a person from a distant location through a communication link.

repeat. In artillery and naval gunfire support, an order or request to fire again the same number of rounds with the same method of fire.

request modify. In artillery and naval gunfire support, a request by any person, other than the person authorized to make modification to a fire plan.

resolution. A measurement of the smallest detail that can be distinguished by a sensor system under specific conditions.

rest. In artillery, a command that indicates that the unit or gun to which it is addressed shall not follow up fire orders during the time that the order is in force

restrictive fire area (RFA). An area in which specific restraints have been imposed and into which fires in excess of those restraints will not be delivered without approval of the establishing authority.

restrictive fire line (RFL). A line established to coordinate fires between heliborne or airborne forces and linkup forces or between any converging friendly forces.

restrictive fire plan. A safety measure for friendly aircraft that establishes airspace that is reasonably safe from friendly surface-delivered fires.

retard. A request from a spotter to indicate that the illuminating projectile burst is desired later in relation to the subsequent burst of high explosive projectiles.

routine MEDEVAC. Evacuation of deceased personnel, a patient with a minor illness, or a patient requiring transfer between medical facilities for further treatment.

routine mission. Administrative or tactical transport of personnel or equipment where time is not a critical factor and delay will not endanger lives or loss of material.

rules of engagement (ROE). Directives issued by competent military authority which specify the circumstances and limitations under which forces will initiate and/or continue combat engagement with other forces encountered.

S

sabot. Lightweight carrier in which a subcaliber projectile is centered to permit firing the projectile in the larger caliber weapon. The carrier fills the bore of the weapon from which the projectile is fired; it is normally discarded a short distance from the muzzle.

safe area. A designated area in hostile territory that offers the evader or escapee a reasonable chance of avoiding capture and of surviving until he can be evacuated.

salvo. In naval gunfire support, a method of fire in which a number of weapons are fired at the same target simultaneously. In close air support or air interdiction operations, a method of delivery in which the release mechanisms are operated to release or fire all ordnance of a specific type simultaneously.

scheduled fire. A type of prearranged fire executed at a predetermined time.

scheduled target. In artillery and naval gunfire support, a planned target on which fire is to be delivered at a specific time.

schedule of fire. Groups of fires or series of fires fired in a definite sequence according to a definite program. The time of starting the schedule may be on call. For identification purposes, schedules may be referred to by a code name or other designation.

schedule of targets. In artillery and naval gunfire support, individual targets, groups, or series of targets to be fired on in a definite sequence according to a definite program.

scotopic vision. That vision produced as a result of the response of the rods in the retina as the eye achieves a dark adapted state (commonly referred to as night vision).

S-day. A date used in the wartime manpower planning system data base to denote the first mobilization manpower action in the scenario, when the first action does not coincide with M-day.

searching fire. Fire distributed in depth by successive changes in the elevation of a gun.

secondary armament. In ships with multiple-size guns installed, that battery consisting of guns next largest to those of the main battery.

sector of fire. An area that is required to be covered by fire by an individual, a weapon, or a unit.

secure area. In helicopterborne operations, an area that has not received hostile fire for 72 hours and in which helicopters will most likely not be subject to fire during the approach, landing, takeoff, or departure phase of operation.

selective identification feature (SIF). A capability that, when added to the basic identification friend or foe system, provides the means to transmit, receive, and display selected coded replies.

semiactive homing guidance. A system of homing guidance wherein the receiver in the missile utilizes radiations from the target that has been illuminated by an outside source.

sensor. Equipment that detects and may indicate and/or record objects and activities by means of energy or particles emitted, reflected, or modified by objects.

sensor control and management platoon (SCAMP). A unit organized under division intelligence to ensure efficient utilization of seismic and other sensor devices.

series of targets. In artillery and naval gunfire support, a number of targets and/or group(s) of targets planned to support a maneuver phase. A series of targets may be indicated by a nickname.

sheaf. In artillery and naval gunfire support, planned planes of fire that produce a desired pattern of bursts with rounds fired by two or more weapons.

shifting fire. Fire delivered at constant range at varying deflections; used to cover the width of a target that is too great to be covered by an open sheaf.

ship will adjust. In naval gunfire support, a method of control in which the ship can see the target and, with the concurrence of the spotter, will adjust.

shore fire control party (SFCP). A specially trained unit for control of naval gunfire in support of troops ashore, consisting of a spotting team to adjust fire and a naval gunfire liaison team to perform liaison functions for the supported battalion commander.

short. In artillery and naval gunfire support, a spotting or an observation used by an observer to indicate that a burst occurred short of the target in relation to the spotting line.

shot. In artillery and naval gunfire support, a report that indicates a gun or guns have been fired.

side looking airborne radar (SLAR). An airborne radar, viewing at right angles to the axis of the vehicle, that produces a presentation of terrain or moving targets.

signal intelligence (SIGINT). A category of intelligence information comprising all communication intelligence, electronics, and telemetry intelligence.

signal-to-noise ratio. The ratio of the amplitude of the desired signal to the amplitude of noise signals at a given point in time.

slant range. The distance between a weapon and the target at the instant of firing or release.

small-scale map. A map having a scale smaller than 1:600,000.

special patrol insertion/extraction (SPIE) system. A system for rapidly extracting reconnaissance patrols from areas that do not permit helicopter landing.

special sheaf. In artillery and naval gunfire support, any sheaf other than parallel, converged, or open.

splash. In artillery and naval gunfire support, word transmitted to an observer or spotter 5 seconds before the estimated time of the impact of a salvo or round.

spot. To determine by observation deviations of ordnance from the target for the purpose of supplying necessary information for the adjustment of fire.

spotter. An observer stationed for the purpose of observing and reporting results of naval gunfire to the firing agency and who also may be employed in designating targets.

spotting. A process of determining by visual or electronic observation deviations of artillery or naval gunfire from the target in relation to a spotting line for the purpose of supplying necessary information for the adjustment or analysis of fire.

spotting line. Either the gun-target line, the observer-target line, or a reference line used by the spotter or observer in making spot corrections.

spreading fire. A notification by the spotter or the naval gunfire ship, depending on who is controlling the fire, to indicate that fire is about to be distributed over an area.

starlight. The illuminance provided by the available (observable) stars in a subject hemisphere.

stereophonic. The visual perception of objects as three dimensional rather than as all in one plane; depth perception.

stick (air transport). A number of paratroopers who jump from one aperture or door of an aircraft during one run over a drop zone.

summit. The highest altitude above mean sea level that a projectile reaches in its flight from the gun to the target; the algebraic sum of the maximum ordinate and the altitude of the gun.

supporting arms. Air, sea, and land weapons of all types employed to support ground units.

supporting arms coordination center (SACC). A single location on board an amphibious command ship in which all communication facilities incident to the coordination of fire support of the artillery, air, and naval gunfire are centralized. This is the naval counterpart to the fire support coordination center utilized by the landing force.

supporting artillery. Artillery that executes fire missions in support of a specific unit, usually infantry, but remains under the command of the next higher artillery commander.

supporting fire. Fire delivered by supporting units to assist or protect a unit in combat.

suppression. Temporary or transient degradation of the performance of a weapon system below the level needed to fulfill its mission objectives by an opposing force.

suppression of enemy air defenses (SEAD). That activity which neutralizes, destroys, or temporarily degrades enemy air defenses in a specific area by physical attack and/or electronic warfare.

suppressive fire. Fires on or about a weapon system to degrade its performance below the level needed to fulfill its mission objectives during the conduct of the fire mission.

surveillance. The systematic observation of aerospace, surface or subsurface areas, places, persons,

or things by visual, aural, electronic, photographic, or other means.

sustained rate of fire. Actual rate of fire that a weapon can continue to deliver for an indefinite length of time without seriously overheating.

T

tactical air command center (TACC). The principal USMC air operation installation from which aircraft and air warning functions of tactical air operations are directed. It is the senior agency of the MACCS from which the tactical air commander can direct and control tactical air operations and coordinate such air operations with other services.

tactical air commander (TAC). The officer (aviator) responsible to the landing force commander for control and coordination of air operations within the landing force commander's area of responsibility when control of these operations is passed ashore.

tactical air control center (TACC). The principal Navy air operation installation from which all aircraft and air warning functions of tactical air operations are controlled.

tactical air control group (TACGRU). An administrative and tactical component of an amphibious force that provides aircraft control and warning facilities afloat for offensive and defensive missions within the tactical air command area of responsibility.

tactical air controller (TAC). The officer in charge of all operations of the tactical air control center. This officer is responsible to the tactical air officer for the control of all aircraft and air warning facilities within the area of responsibility.

tactical air control party (TACP). A subordinate operational component of a tactical air control system designed to provide air liaison to land forces and for the control of aircraft.

tactical air control squadron (TACRON). An administrative and tactical component of the tactical air control group that provides the control mechanism for the ship-based tactical air direction center or the tactical air control center.

tactical air coordinator (airborne) (TAC(A)). An officer who coordinates, from an aircraft, the action of combat aircraft engaged in close support of ground or sea forces.

tactical aircrew mission planning system (TAMPS). A computer-based mission planning system designed to streamline the mission planning process.

tactical air direction center (TADC). An air operation installation under the overall control of the TACC from which aircraft and air warning service functions of tactical air operations in an area of responsibility are directed.

tactical air director (TAD). The officer in charge of all operations of the tactical air direction center. When operating independently of a TACC (afloat), the tactical air director assumes the functions of the tactical air controller.

tactical air observer (TAO). An officer trained as an air observer whose function is to observe from aircraft and report on movement and disposition of friendly and enemy forces; on terrain, weather, and hydrography; and to execute other missions as directed.

tactical air officer (afloat) (TAO). The officer (aviator) under the amphibious task force commander who coordinates planning of all phases of air participation of the amphibious operation and air operation supporting forces en route to and in the objective area.

tactical air operation center (TAOC). A subordinate operational component of the MACCS designed for direction and control of all en route air traffic and surface-to-air weapons in an assigned sector. It is under the operational control of the TACC.

tactical air reconnaissance. The use of air vehicles to obtain information concerning terrain, weather, and the disposition, composition, movement, installations, lines of communications, electronic and communication emissions of enemy forces. Also included are artillery and naval gunfire adjustment, and systematic and random observation of ground battle areas, targets, and/or sectors of airspace.

tactical area of responsibility (TAOR). A defined area of land for which responsibility is specifically assigned to the commander of the area as a measure for control of assigned forces and coordination of support.

tactical intelligence. Intelligence that is required for the planning and conduct of tactical operations.

tactical lead. A member of the flight that has the best grasp of the tactical situation. The tactical lead may

change several times during the conduct of a mission; however, the tactical leader never usurps the responsibilities of the NATOPS flight leader.

tactical operation area. That area between the fire support coordination line and the rear operation area where maximum flexibility in the use of airspace is needed to assure mission accomplishment. The rear boundary of the tactical operation area should normally be at or near the rear boundary of the frontline divisions.

"TALLY". Refers to visual contact with an enemy aircraft or flight. "TALLY," "NO TALLY," "TALLY ONE," and "TALLY TWO," are calls used to establish the extent of a crew's contact with a section of enemy aircraft.

target acquisition. The detection, identification, and location of a target in sufficient detail to permit the effective employment of weapons.

target classification. A grouping of targets in accordance with their threat to the amphibious task force and its component elements: targets not to be fired upon prior to D-day and targets not to be destroyed except on direct order.

target discrimination. The ability of a surveillance or guidance system to identify or engage any one target when multiple targets are present.

target folder. A folder containing target intelligence and related materials prepared for planning and executing action against a specific target.

target grid. Device for converting the observer's target locations and corrections with respect to the observer target line to target locations and corrections with respect to the gun target line.

target information sheet. Brief description of the target, completing the descriptive target data. It should include technical and physical characteristics, details on exact location, disposition, importance, and possible obstacles for an aircraft flying at low altitudes.

targeting. The process of selecting targets and matching the appropriate response to them, taking account of operational requirements and capabilities.

target intelligence. Intelligence that portrays and locates the components of a target or target complex and indicates its vulnerability and relative importance.

target list. The listing of targets maintained and promulgated by the senior echelon of command; it contains those targets that are to be engaged by supporting arms, as distinguished from a list of targets that may be maintained by any echelon as confirmed, suspect, or possible targets for informational and planning purposes.

target number. The reference number given to the target by the fire control unit.

target overlay. A transparent sheet that, when superimposed on a particular chart, map, drawing, tracing, or other representation, depicts target locations and designations. The target overlay may also show boundaries between maneuver elements, objectives, and friendly forward dispositions.

task organization. An organization that assigns to responsible commanders the means with which to accomplish their assigned tasks in any planned action.

"TERMINATE." Call made to end a single engagement or maneuver. During training, it is used when the learning objectives are met or safety parameters are exceeded.

terrain flight. Flight close to the Earth's surface during which airspeed, height, and/or altitude are adapted to the contours and cover of the ground in order to avoid enemy detection and fire.

thermal crossover. The natural phenomenon that normally occurs twice daily when temperature conditions are such that there is a loss of contrast between two adjacent objects on infrared imagery.

thermal imagery. Imagery produced by sensing and recording the thermal energy emitted or reflected from the objects that are imaged.

thermal radiation. Electromagnetic radiation emitted from a heat or light source as a consequence of its temperature.

thermal shadow. The tone contrast difference in infrared line-scan imagery that is caused by a thermal gradient that persists as a result of a shadow of an object that has been moved.

time of flight (TOF). In artillery and naval gunfire support, the time in seconds from the instant a weapon is fired, launched, or released from the delivery vehicle or weapon system to the instant it strikes or detonates.

time on target (TOT). Time at which aircraft are scheduled to attack or photograph the target; the actual time at which aircraft attack or photograph the target. The method of firing on a target in which various artillery units and naval gunfire support ships so time their fire as to assure the initial rounds strike the target simultaneously at the time required.

time-sensitive targets. Those targets requiring immediate response because they pose (or will soon pose) a clear and present danger to friendly forces or are highly lucrative, fleeting targets of opportunity.

time to target (TTT). Number of minutes and seconds to ordnance on target.

track crossing angle. Determined by noting the heading difference between two aircraft. It is a measure of the number of degrees needed to turn to be aligned with another aircraft's heading. Track crossing angle is sometimes referred to as heading crossing angle.

transport flight leader. An experienced aviator in command of the transport helicopters taking part in a helicopterborne mission.

twilight. The periods of incomplete darkness following sunset and preceding sunrise. Twilight is designated as civil, nautical, or astronomical, as the darker limit occurs when the center of the sun is 6°, 12°, or 18°, respectively, below the celestial horizon.

U

universal transverse mediator grid (UTM). A grid coordinate system based on the transverse mediator projection, applied to maps of the Earth's surface.

unobserved fire. Fire for which the points of impact or burst are not observed.

up. In artillery and naval gunfire support:

1. A term used in a call for fire to indicate that the target is higher in altitude than the point that has been used as a reference point for the target location.

2. A correction used by an observer or a spotter in time fire to indicate that an increase in height of burst is desired.

urgent MEDEVAC. Evacuation of critically wounded, injured, or ill personnel who require early hospitalization and whose immediate evacuation is a matter of life or death.

urgent priority. A category of immediate mission request that is lower than emergency priority but takes precedence over ordinary priority.

V

vital area. A designated area or installation to be defended by air defense units.

"VISUAL." Refers to contact with an aircrew's wingman. "VISUAL" and "NO VISUAL" are used to establish the extent of an aircrew's contact with other aircraft in the same flight.

W

weapon/fighter engagement zone (WEZ/ FEZ). In air defense, airspace of defined dimensions within which the responsibility for engagement normally rests with a particular weapon system.

weapons free. In air defense, a weapon control status used to indicate that weapon systems may be fired at any target not positively identified as friendly.

weapons hold. In air defense, a weapon control status used to indicate that weapon systems may be fired only in self-defense or in response to a formal order.

weapons tight. In air defense, a weapon control status used to indicate that weapon systems may be fired only at targets identified as hostile.

will not fire. A term sent to the spotter or other requesting agency to indicate that the target will not be engaged by the fire support ship.

wind direction indicator. A lightly weighted strip of material that may be dropped prior to a paradrop to estimate wind drift.

windline. A line through the center of a drop zone that is parallel to the surface wind.

wrong. A proword meaning that the last transmission was incorrect, followed by the correct transmission.

Z

ZIP LIP. A condition that may be prescribed during flight operations regarding radio transmission. Only transmissions requisite to safety of flights are permitted.

ZIPPO brief. Zone inspection, planning, preparation, and operational evaluation brief.

zone fire. Artillery or mortar fires that are delivered in a constant direction at several quadrant elevations.

zone of fire. An area within which a designated ground unit or fire support ship delivers or is prepared to deliver fire support. Fire may or may not be observed.

PREFACE

SCOPE

The OV-10, Vol I Tactical Manual, prepared under the direction of the Commander Operational Test and Evaluation Force with MAWTS-1 designated as Model Manager and approved by the Chief of Naval Operations, contains the latest information regarding the tactical employment of the OV-10 aircraft.

Information contained in this manual has been derived from many sources to provide one main source for procedures, techniques, and data to enable the pilot to most effectively employ the aircraft and its weapons system in combat. The NATOPS Flight Manual standardizes ground and flight training procedures and contains the information to thoroughly acquaint the pilot with the aircraft. Information in this manual is primarily oriented to tactical employment of the aircraft which presupposes a thorough knowledge of the NATOPS Flight Manual. A description of the Aircraft Tactical Manual program is contained in NWP 0.

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Recommended changes to this manual may be submitted by anyone in accordance with NWP 0. Submit Routine Change recommendations to the Model Manager on OPNAV Form 3500/22 (see the following sample form). Address Routine Changes to Commanding Officer, ATTN: OV-10s, MAWTS-1, MCAS YUMA, AZ 85369-6073. Submit recommendations of an Urgent nature directly to your Type Commander by Priority message (see the following sample message form).

INTERIM CHANGE SUMMARY

The Interim Change Summary is provided for the purpose of maintaining a complete record of all Interim Changes issued to the manual. Each time the manual is changed or revised, the Interim Change Summary will be formally updated to indicate disposition and/or incorporation of previously issued Interim Changes. When a regular change or revision

URGENT CHANGE RECOMMENDATION MESSAGE FORMAT FOR NWP 55-SERIES TACTICAL MANUALS

Precedence: Action - PRIORITY; Info - ROUTINE
FROM: (originating unit)//***//
TO: (your TYPE COMMANDER)//***//
INFO: **CNO WASHINGTON DC//50/73//**
COMNAVAIRSYSCOM WASHINGTON DC//511/530/540//
COMOPTEVFOR NORFOLK VA//02B//50//
TACMAN MODEL MANAGER UNIT//*//** (for NWP involved)
YOUR CHAIN OF COMMAND//*//** (as appropriate)
NAVTACSUPPACT WNY DET WASHINGTON DC//60//
NAVAIRTESTCEN PATUXENT RIVER MD//SA80/SA84//
NAVSAFECEN NORFOLK VA//113C//
CG MCCDC QUANTICO VA//WF12C/TE31A// (if USMC activities involved)
MAWTS ONE YUMA AZ//JJJ// (if USMC activities involved)
Interrested activities

(SECURITY CLASSIFICATION) **//N03511//**

SUBJ: URGENT CHANGE RECOMMENDATION TO OV-10A/D Vol I, TACTICAL MANUAL (U)
MSGID/GENADMIN/(originator's unit)//
REF/A/DOC/CNO/(date of latest change or revision to NWP 0)//
AMPN/REF A IS NWP 0 REV ___//
REF/B/DOC/NAVAIR/(date of latest TACMAN change or revision)//
AMPN/REF B IS NAVAIR (number) **/NWP** (number) (include volume number and change number if applicable)//

(include more REF sets with AMPN/NARR sets as necessary to give complete background to change recommendation.)

RMKS/1. (*) IAW REF A, RECOMMEND CHANGE(S) TO REF B AS FOLLOWS:

A.(*) Identify PART, CHAP., PG., FIG., PARAGRAPH, SENTENCE.
(1) (*) **DELETE:** (Always indicate material to be deleted. If no deletion is necessary, indicate by NA).
(2) (*) **ADD:** (Indicate new or changed material. If no new material is necessary, indicate by NA).

B.(*) (continue with change recommendations as necessary).
2. (*) (remarks to support change recommendation)//

DECL/ (downgrading or declassification instructions)//

Symbol key:
***Show message routing code(s), or "JJJ" when required but unknown.

*Include classification marking of SUBJ line, paragraph, and subparagraphs.
Note - Refer to NTP-3 for detailed GENADMIN format instructions.

NATOPS/TACTICAL CHANGE RECOMMENDATION
OPNAV 3710/6 (4-90) S/N 0107-LF-009-7900

DATE ____________

TO BE FILLED IN BY ORIGINATOR AND FORWARDED TO MODEL MANAGER

FROM (originator)				Unit	
TO (Model Manager)				Unit	
Complete Name of Manual/Checklist	Revision Date	Change Date	Section/Chapter	Page	Paragraph

Recommendation (be specific)

CHECK IF CONTINUED ON BACK

Justification

Signature	Rank	Title

Address of Unit or Command

TO BE FILLED IN BY MODEL MANAGER *(Return to Originator)*

FROM	DATE

TO

REFERENCE

(a) Your Change Recommendation Dated ____________

Your change recommendation dated ____________ is acknowledged. It will be held for action of the review conference planned for ____________ to be held at ____________

Your change recommendation is reclassified URGENT and forwarded for approval to ____________ ____________ by my DTG ____________

/S/ ____________ MODEL MANAGER ____________ AIRCRAFT

is received, the Interim Change Summary should be checked to ascertain that all outstanding Interim Changes have been formally incorporated or canceled. Those changes that were not incorporated should be noted as applicable. The Tactical Publications Status Report published monthly by the Navy Tactical Support Activity contains a summary of latest changes to all Tactical Manuals.

CHANGE SYMBOLS

Revised text is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol shows where there has been a change. The change might be material added or information restated.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to "WARNINGS," "CAUTIONS," and "Notes" found throughout the manual:

WARNING

An operating procedure, practice, or condition, etc., which may result in injury or death if not carefully observed or followed.

CAUTION

An operating procedure, practice, or condition, etc., which may result in damage to equipment if not carefully observed or followed.

Note

An operating procedure, practice, or condition, etc., which is essential to emphasize.

WORDING

The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is optional.

"Will" has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

PART I

Air-to-Ground Warfare

CHAPTER 1

Aircraft Weapon Systems

1.1 AIRCRAFT DESCRIPTION

The OV-10 is a twin-turboprop, multipurpose aircraft designed for counter-insurgency operations. Main identification features include a straight shoulder-mounted wing, a large cockpit canopy, twin tail booms, and swept vertical stabilizers connected by a high-set horizontal stabilizer. The tandem cockpit section is partially armor-plated to provide protection from small arms penetration. The rear cockpit section contains a second flightcrew station (observer's) with either message drop capability or a KB-18 camera mounting station. The rear cockpit of the OV-10D contains the primary FLIR/LRD control equipment. Two canted sponsons are mounted on the lower fuselage, providing four external stores stations and internal housing for the four 7.62-mm machineguns. An additional weapon or single external fuel tank may be carried on the centerline store station under the fuselage between the sponsons.

The aircraft armament system is provided for the carriage, control, and expenditure of various ordnance weapons, sensors, rockets, missiles, and guns. The aircraft is capable of carrying a variety of conventional weapon loads, including gun pods, bombs, aerially delivered sensors, rocket pods, and napalm. Authorized external stores, carriage, and release limits are listed in Appendix A. The armament controls are located in the pilot's cockpit and include the weapon control panel (Figures 1-1 and 1-2), station mode panel (Figure 1-1), missile (Figure 1-5), control stick switches, emergency stores jettison handle, and stores emergency release button (Figure 1-3). (The armament system for the OV-10D SLEP is covered in paragraph 1.4.)

The aircraft is provided with seven external store stations. They consist of two wing pylon stations, four fuselage sponson stations, and a centerline fuselage station. The fuselage stations are numbered 1 through 5 consecutively, from left to right (see Figure 1-6).

1.2 WEAPON SYSTEMS

1.2.1 Weapon Control Panel

1.2.1.1 Master Armament Switch. All armament equipment is controlled by the MASTER ARM switch (Figures 1-1 and 1-2). The armament circuits can be energized only when this switch is ON. An armament safety circuit prevents operation of the armament system when the landing gear handle is down.

The MASTER ARM switch is on the far right side of the weapon control panel, which is located on the left-hand side of the instrument console. The MASTER ARM switch provides power to the armament bus.

1.2.1.2 Bomb-Flare Arm Switch. The BOMB-FLARE ARM switch (Figures 1-1 and 1-2) is located on the right side of the weapon control panel. The switch has three positions designated NOSE & TAIL, TAIL, and SAFE. Placing the switch in the NOSE & TAIL position energizes both arming solenoids on each bomb rack. Placing the switch in the TAIL position energizes only the tail arming solenoid on each bomb rack. In the SAFE position, the system is not energized. The MASTER ARM switch must be in the ON position to enable the BOMB-FLARE ARM switch to function. This switch also safes and controls firing rates of the GPU-2A. For low rate of fire (750 rpm), the SAFE position is selected. For high rate of fire (1,500 rpm), the TAIL position is selected. The NOSE & TAIL position safes the gun. With AFC 84 incorporated, the GPU battery receives a trickle charge from the monitor dc bus.

1.2.1.3 Left and Right Gun Switches. On the OV-10A, the LH and RH GUNS switches are located on the far left side of the weapon control panel (Figure 1-1) and are used to select RDY (ready) or CLEAR condition of the fixed M60C sponson-mounted machineguns. On the OV-10D, these switches are

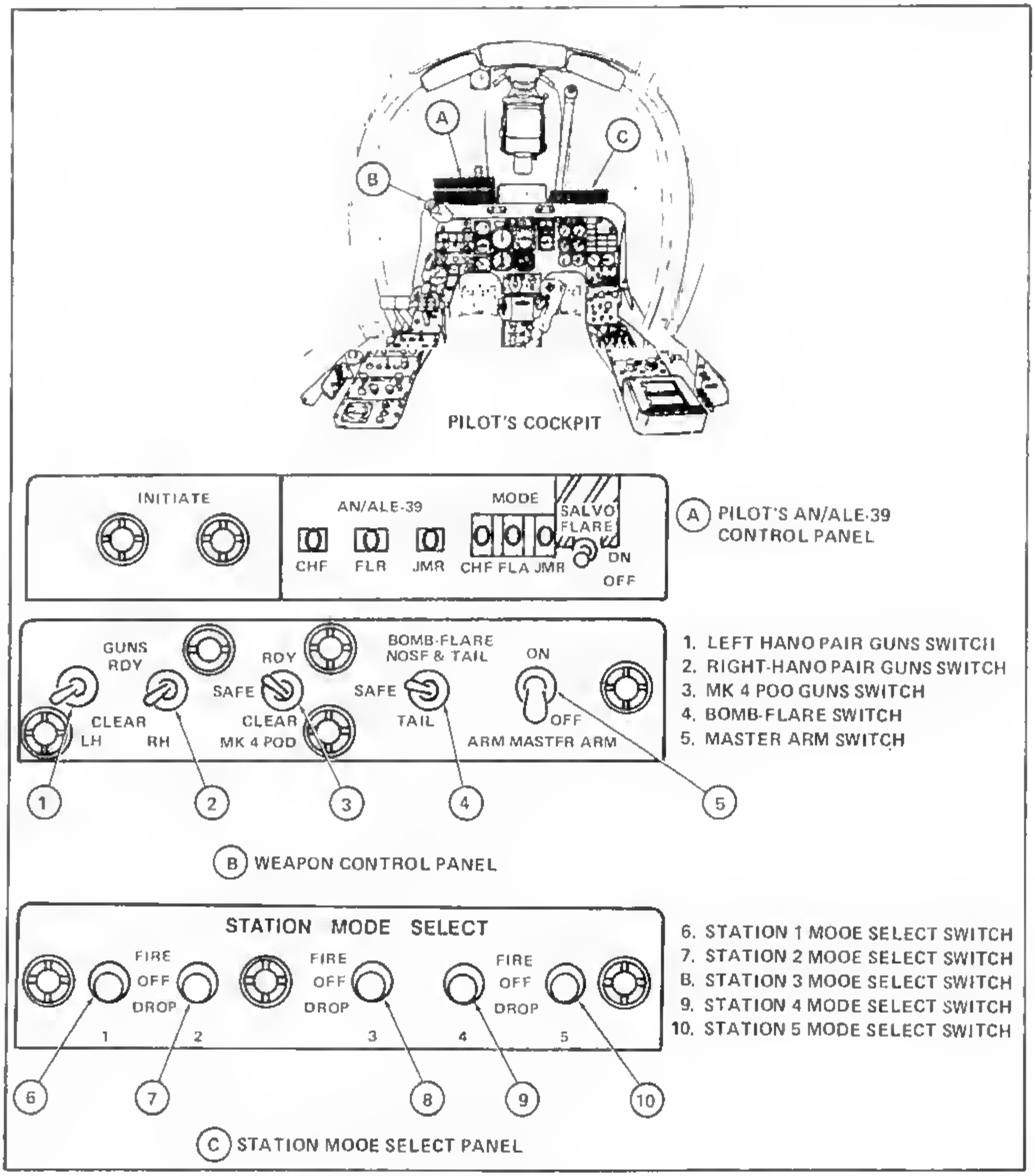
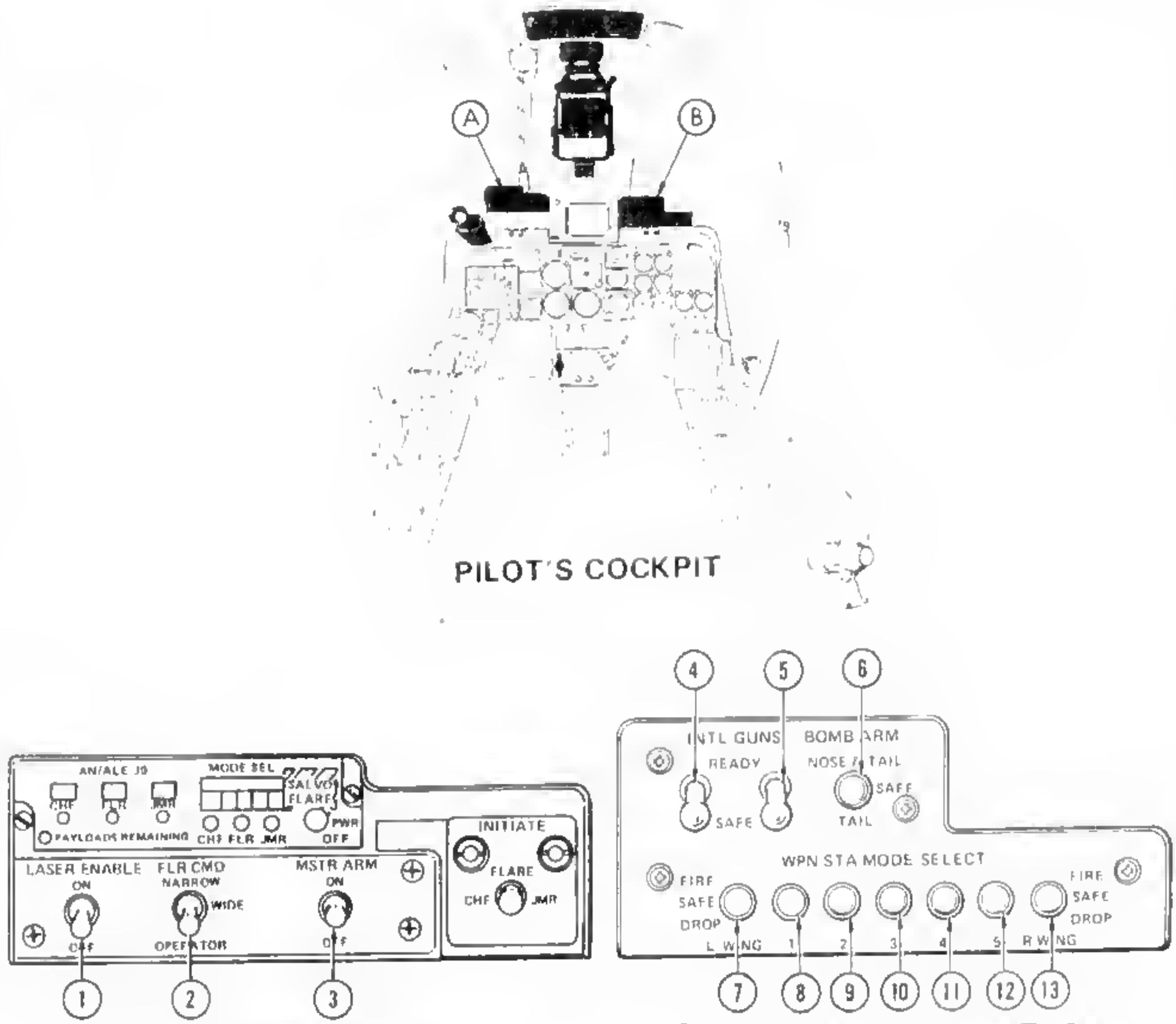


Figure 1-1. Weapon Control and Station Mode Select Panels (A)



Ⓐ **FLIR/WEAPONS CONTROL**

1. LASER ENABLE SWITCH
2. FLIR COMMAND SWITCH
3. MASTER ARMAMENT SWITCH

Ⓑ **RH WEAPONS CONTROL**

4. LEFT-HAND INTERNAL GUNS SWITCH
5. RIGHT-HAND INTERNAL GUNS SWITCH
6. BOMB ARM SWITCH
7. L. WING MODE SELECT SWITCH
8. STATION 1 MODE SELECT SWITCH
9. STATION 2 MODE SELECT SWITCH
10. STATION 3 MODE SELECT SWITCH
11. STATION 4 MODE SELECT SWITCH
12. STATION 5 MODE SELECT SWITCH
13. R. WING MODE SELECT SWITCH

OV-10D-1-68A

Figure 1-2. Weapon Control Panel (D)

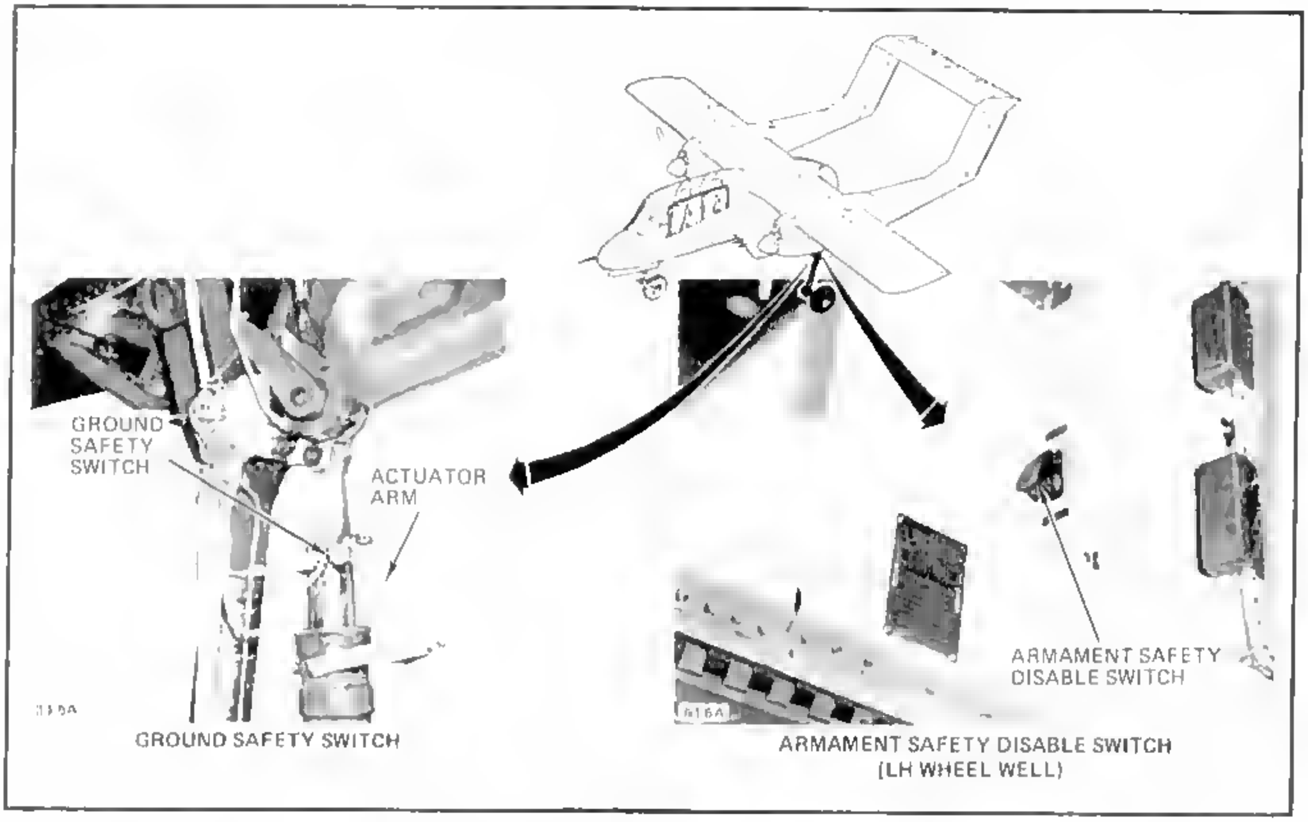


Figure 1-3. Armament Safety Switches (A)/(D)

located in the upper left-hand corner of the weapon control panel above the right console. These guns may be fired in selected pairs or simultaneously. The fixed gun-charging mechanism may be ground-checked through use of an auxiliary gun charger switch in each sponson.

CAUTION

When using the LH and RH GUNS switches to arm the fixed guns, a 3- to 5-second delay must be observed before moving the gun switches to the CLEAR position, and a 3- to 5-second delay after that before moving the MASTER ARM switch to OFF, to prevent a jam and allow sufficient time for the guncharging rods to travel to the rear.

Note

The OV-10A Mk 4 POD READY/SAFE CLEAR switch is inoperative.

1.2.2 Station Mode Select Panel

1.2.2.1 Station Mode Select Switches. The STATION MODE SELECT switches (Figures 1-1 and 1-2) are used to select external ordnance for FIRE or DROP as required. The OFF/SAFE position is used to disable the bomb release button circuits. The STATION MODE SELECT switches operate with the bomb release button as follows:

STATION MODE	ORDNANCE
FIRE	Gun pods, rockets, and dispensers
OFF	Safe
DROP	Normally dropped ordnance

1.2.3 Control Stick Switches

1.2.3.1 Bomb Release Button. The bomb release button is located on the pilot's stick grip. This button is used to drop or fire all ordnance except the internal machineguns.

1.2.3.2 Trigger. The trigger is located on the forward face of the pilot's stick grip. This switch is used to fire the (internal) sponson guns only.

1.2.4 Stores Emergency Release

1.2.4.1 Stores Emergency Release (STORES EMER REL) Button. The STORES EMER REL button (Figure 1-4), when depressed, releases all external stores from the fuselage (and OV-10D wing) stations. The stores emergency release system, powered by the battery bus, is operative only with the aircraft airborne. The emergency release system is independent of the MASTER ARM switch.

Note

Unarmed emergency release requires that the MASTER ARM switch be positioned to OFF, or that the BOMB-FLARE ARM/BOMB ARM switch be in the SAFE position.

1.2.4.2 Emergency Stores Jettison (EMER ST JETT) Handle. The EMER ST JETT handle (Figure 1-4) is located on the pilot's center pedestal. All stores on the sponson stations (1, 2, 4, and 5) are jettisoned manually by pulling the handle outward approximately 3 inches. The wing pylon stations will not be jettisoned.

Note

- Unarmed emergency jettison requires that the MASTER ARM switch be positioned to OFF or the BOMB-FLARE ARM/BOMB ARM switch be in the SAFE position.
- If desired, the external fuel tank(s) may be retained and all other stores released by pulling the EMER ST JETT handle.

1.2.5 Armament Safety

1.2.5.1 Ground Safety Switch. The ground safety switch is located on the left main landing gear strut (Figure 1-3). During ground conditions (weight of the aircraft on the landing gear), the ground safety switch disables the stores emergency release system. During flight conditions (weight of the aircraft off the landing gear), the ground safety switch enables operation of the stores emergency release system.

1.2.5.2 Armament Safety Disable Switch. The ARMT SAFETY DISABLE switch is located inside the left main landing gear well (Figure 1-3) and is guarded with a red safety cover. This switch is spring loaded to the DISABLE position. For ground maintenance of the armament system, activation of this switch provides power to the armament bus without the normal requirements to power the monitor bus or raise the landing gear handle.

This switch can be placed to the enable position to bypass the disable function and allow normal operation of the armament system with the landing gear handle in the down position. This allows ordnance personnel to check the aircraft armament system for proper functioning without having to jack the aircraft up and raise the landing gear.

1.2.6 Optical Sight. An illuminated, reflecting, noncomputing optical sight (Figure 1-4) is installed in the cockpit. The sight reticle may be depressed as much as 270 mils from the zero sight line by tilting the reflecting glass to provide proper sight angles for release slant range or lead angles for all types of munitions. The reticle image consists of a 2-mil pipper and quadrantal marking rings at 25 and 50 mils with cardinal lines of alternating 10-mil marks and spaces. Release of high drag munitions may require sight depression angles exceeding 270 mils under some conditions. Depression angles of 325 mils may be obtained by setting the depression lever to 270 mils and using the end point of the lower vertical index (cardinal line), which is 55 mils below the pipper. Sight elevations of less than 0 mils depression are not available. Up to 55 mils elevation may be obtained by setting the depression lever to 0 mils and using the upper end of the vertical index (55 mils above the pipper). The optical sight installation includes a slip indicator (Figure 1-4) that provides heads-up detection of yawed flight during munition deliveries.

Note

In the A, the available over-the-nose vision is approximately 22.4° (391 mils). In the D, the available over-the-nose vision is approximately 16° (286 mils).

1.2.6.1 Sight Depression Lever. The sight depression lever, located just above the glass housing portion of the sight (Figure 1-4), is used to adjust the depression angle of the sight line, with variable settings from 0 to 270 mils. The depression selected is read directly on the sight body and is indicated in units of MILS X 10.

1.2.6.2 Sun Shield. An adjustable sun shield (Figure 1-4) is installed on the optical sight. This filter may be lifted into position behind the reflecting glass during daylight operation in order to increase contrast between ground objects and the reticle image under bright sunlight conditions.

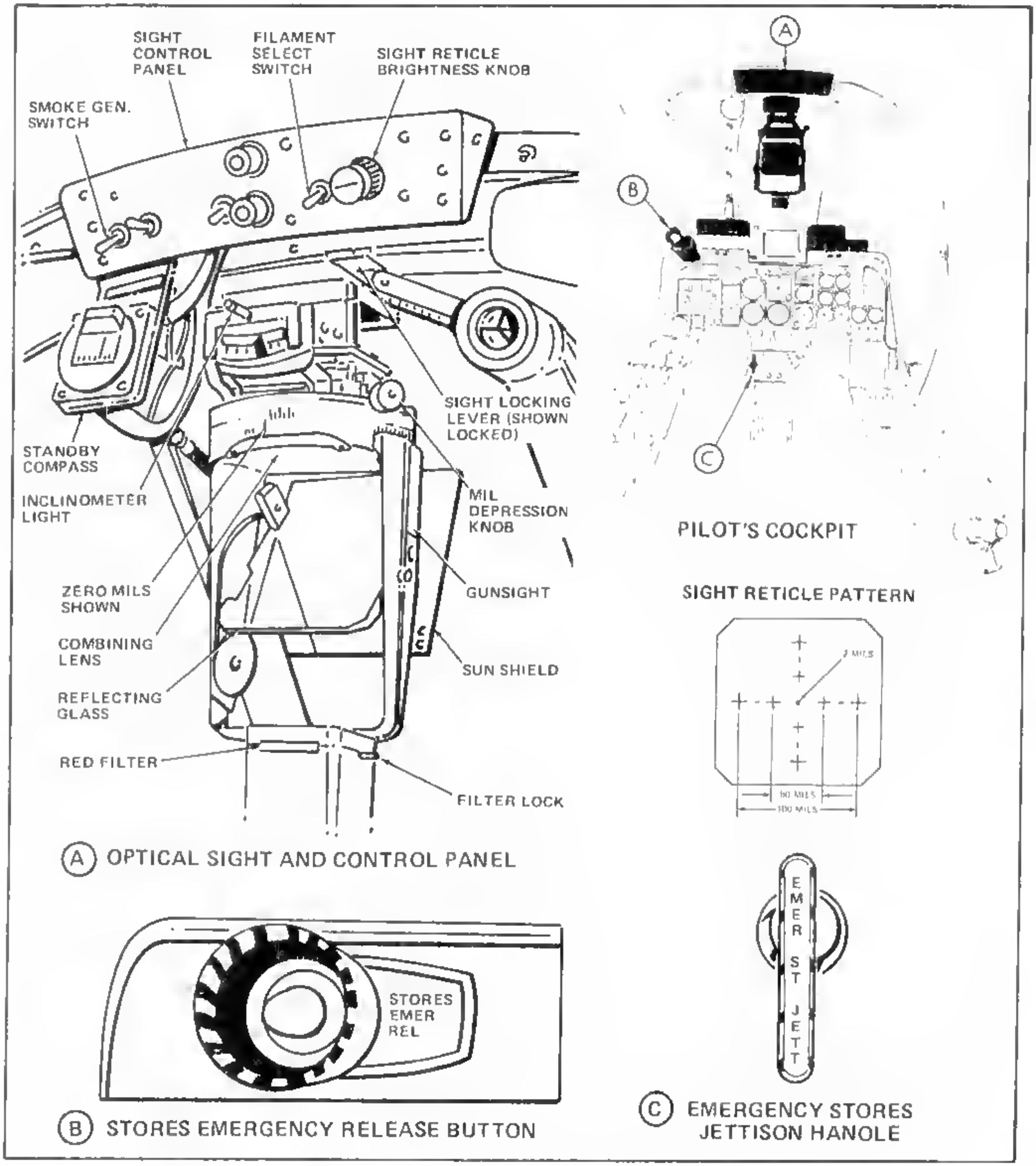


Figure 1-4. Optical Sight and Armament Control

1.2.6.3 Day/Night Reticle Filter. A combination red-white (CLEAR) filter is located between the sight body and reticle housing (Figure 1-4). For daylight operation, the filter is inserted with the DAY marking visible. For night operation, if desired, the filter can be removed and inserted with the RED marking visible. The day/night filter is held by a detent and is changed as desired by pulling straight out, revolving, and reinserting in the holder.

1.2.7 Optical Sight Control Panel. An optical sight control panel (Figure 1-4) is mounted on the canopy frame above the sight. The panel has two controls relating to the sight.

1.2.7.1 Sight Reticle Brightness Knob. The sight reticle brightness knob (Figure 1-4) allows selection of sight reticle illumination and brightness adjustment.

1.2.7.2 Filament Select (FIL SEL) Switch. The FIL SEL switch (Figure 1-4) allows selection of the NO. 1 or NO. 2 sight reticle illuminator filament. Sight reticle brightness and ON/OFF selections are controlled through the sight dimmer knob.

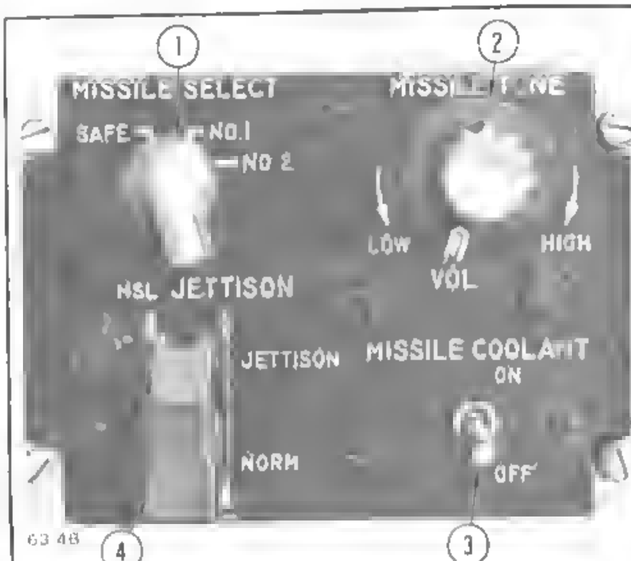
Note

To prolong filament life, leave the gunsight off until required. Select the NO. 1 filament first. If NO. 2 is selected and it burns out, it may simultaneously short out the NO. 1 filament below it.

1.2.8 Missile Control Panel. The missile control panel (Figure 1-5) is mounted in the center pedestal in the pilot's cockpit and is used to select the AIM-9 series missile for firing.

1.2.8.1 MISSILE SELECT Knob. The MISSILE SELECT knob (Figure 1-5) has three positions: SAFE, NO. 1, NO. 2, and MASTER ARM. Selection of station NO. 1 (left wing) or station NO. 2 (right wing) allows the audio tone of the selected missile to be heard. When in addition to selecting station NO. 1 or 2, the MASTER ARM is switched on, the selected missile may be launched by depressing the bomb release button.

If missiles are installed, warmup power to missile electronic components is provided directly with the MASTER ARM switch ON. Moving the MISSILE SELECT knob from SAFE to NO. 1 or NO. 2 allows the audio tone from the selected missile to be heard in the headset with the MSL monitor knob (interphone control panel) pulled up and turned fully on. Missile tone volume is then controlled through the MISSILE TONE VOL knob on the missile control panel. Selecting NO. 1 or NO. 2 also energizes the missile arming circuit (aircraft airborne).



1. MISSILE SELECT KNOB
2. MISSILE TONE VOLUME KNOB
3. MISSILE COOLANT SWITCH
4. MISSILE JETTISON SWITCH

Figure 1-5. Missile Control Panel

1.2.8.2 Missile Tone Volume Knob. The MISSILE TONE VOL knob (Figure 1-5) provides a volume control for the audio tone generated by the missile.

1.2.8.3 MISSILE COOLANT Switch. The MISSILE COOLANT switch (Figure 1-5) is used with the AIM-9H/L/M series missile. The ON position should be selected at least 1 minute prior to firing the missile.

1.2.8.4 Missile Jettison Switch. The MSL JETTISON switch (Figure 1-5) is inoperative.

Note

- Jettisoning requires that the missiles be launched normally, armed and guided.
- The LAU-7/A launcher cannot be jettisoned.

1.2.9 External Stores Suspension System

1.2.9.1 Sponson Stations. Each external store station pylon houses an Aero 65A-1 bomb rack. The racks on sponson station pylons (stations 1, 2, 4, and 5) provide 14-inch suspension capability for stores weighing up to 600 pounds at design g-load. The wing stations on the D are capable of carrying stores up to 750 pounds. Each

rack contains an Aero 7B-1 rack release solenoid, a nose and tail arming solenoid, and hook latch and sear roller inspection holes (Figure 1-6). The centerline pylon rack (station 3) is equipped with Aero 1A adapters, providing an alternate 30-inch suspension capability. The centerline station can carry a single store weighing up to 1,200 pounds at design g-loading. All bomb racks include a rack safety pin access that allows securing the hooks in the closed position after stores are loaded. When munitions are released normally (electrical release with BOMB-FLARE ARM/BOMB ARM switch at NOSE & TAIL or TAIL), the arming solenoids remain closed, retaining the arming wires; withdrawal of the arming wires from the fuzes allows the store to drop in the selected arming condition. The arming solenoids remain electrically closed after the drop, preventing release of the arming wires.

1.2.9.2 Wing-Mounted Pylon Assembly. The wing-mounted pylon assemblies are physically bolted to the underside of each wing, outboard of the engine nacelles, and inboard of the wing tips. In the A, each assembly is a complete unit with wiring and suspension lugs designed to hold the LAU-7/A guided missile launcher. The OV-10D utilizes the ADU-299 in conjunction with the LAU-7/A for missile carriage. Each assembly of the OV-10D is plumbed and wired for compatibility with the 100-gallon external fuel tank.

1.2.9.3 LAU-7/A Series Guided Missile Launcher. The LAU-7/A launcher (Figure 1-7) provides carriage and release of all AIM-9 Sidewinder missiles. The launcher is comprised of several assemblies that provide missile in-flight retention and security, electrical interface between the aircraft and missile, and nitrogen cooling to the missile IR detector.

The cylindrical nitrogen receiver (bottle) located in the aft section of the launcher will provide approximately 2 hours of continuous cooling to the missile IR detector after the cockpit missile cooling switch has been actuated. The internal power supply provides the connection point for the missile umbilical cable and amplifies the missile detector target tone to 1500 Hz for the pilot's headset. Missile control fin retainers, located on both sides of the forward section of the launcher, provide temporary security to prevent in-flight flutter. The forward retainer spring is used for the AIM-9 L/M fins and the aft retainer spring is used for the AIM-9H fins. Ground safety is accomplished by a detent wrench safety pin that mechanically prevents the missile from leaving the launcher if accidentally fired. Refer to NAVAIR 11-75A-54 for additional details.

1.2.9.4 Practice Multiple Bomb Rack (PMBR). The A/A 37B-3 (PMBR) is a removable auxiliary rack designed to carry up to six practice bombs or ADSIDs. The rack (Figure 1-8) consists of a body assembly and six release assemblies. The body assembly consists of a main structural member with a nose fairing, internal electrical cabling to the release assemblies and aircraft, and an aluminum bar with provisions for 14- or 30-inch lug suspension. A release station selector dial, a mode selector switch, and a FIRE-SAFE switch are located in the tail of the rack. Only the station selector dial is operational. Each of the six release assemblies has a single store suspension hook, two integral sway braces, and access holes for rack relatching, sway brace tightening, and manual release.

The station selector is preset to the station to be released first. PMBRs have no bomb arming solenoids and if arming wires are required, they must be positively rigged. The hook on the rack is opened by a solenoid actuated by an electric pulse from the 28 vdc of the aircraft. The store falls away by gravity drop. There is no store sensing capability and empty stations are not automatically bypassed. Stores cannot be safe jettisoned.

Note

The only means to jettison a PMBR is to pull the emergency stores JETT HANDLE.

1.3 AN/ALE-39 COUNTERMEASURES DISPENSING SYSTEM

The AN/ALE-39 countermeasures dispensing system permits the pilot or aerial observer to selectively eject flares, chaff, or active radio devices (jammers) from dispensing pods in the tail booms. These items are designed to defeat enemy surveillance radar, missile guidance radar, and passive homing missiles. The AN/ALE-39 has the capability of dispensing up to sixty chaff, flare, and jammer payloads loaded in any combination in multiples of 10. All three types of payloads can be dispensed in both manual (single) and automatic (programmed) modes independently or simultaneously. The cockpit components of the AN/ALE-39 consist of the pilot's countermeasures dispenser control panel and initiate switch (Figures 1-1 and 1-2). In the OV-10D SLEP the countermeasures control is part of the CMS-80. For more information, see A1-010DA-NFM-000, OV-10D SLEP NATOPS Flight Manual.

1.4 OV-10D SLEP ARMAMENT SYSTEM

The aircraft is capable of carrying a variety of conventional weapons loads, including gun pods, bombs, missiles, rocket pods, CBUs, and napalm. Weapon display and control functions are selected from the

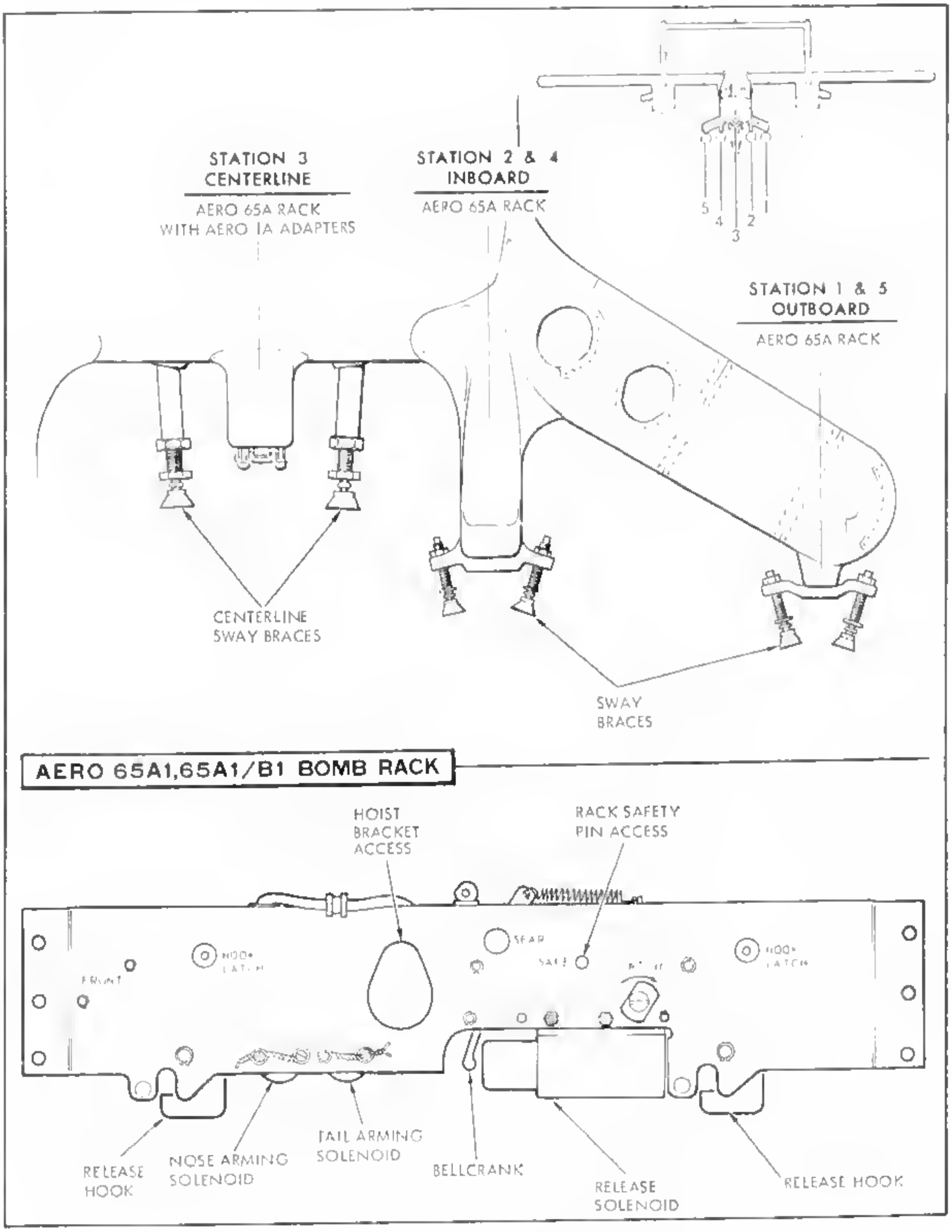


Figure 1-6. Munition Suspension Systems (A)/(D)

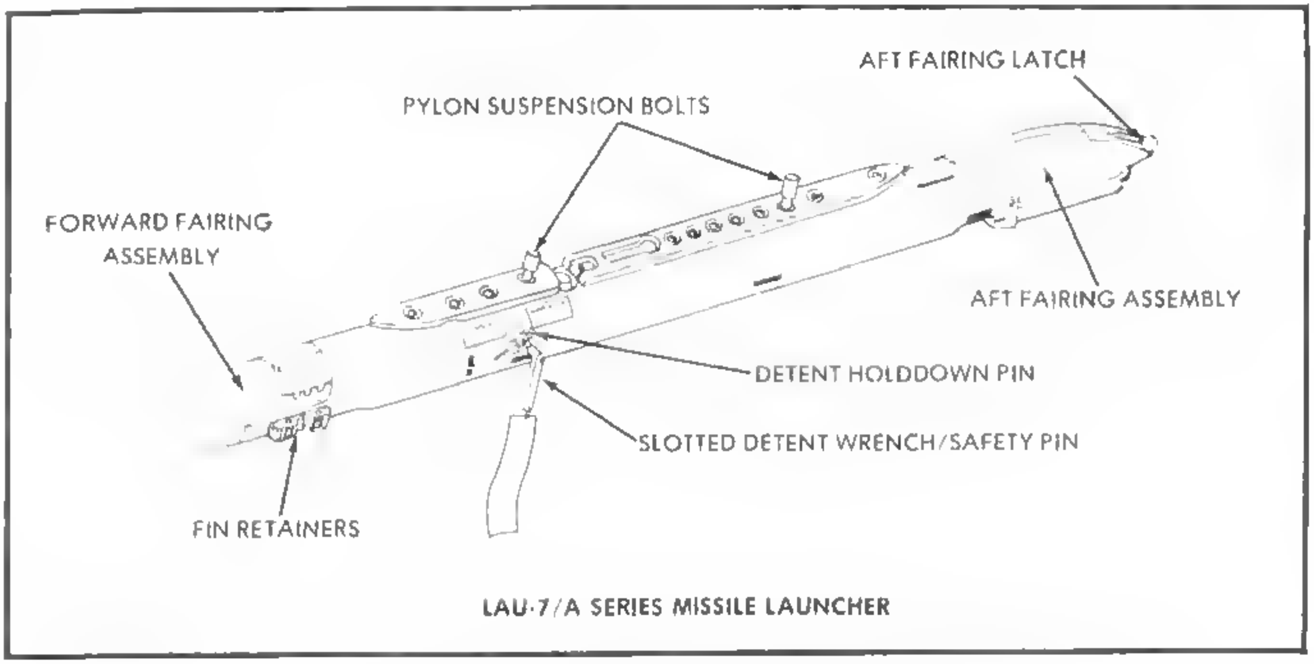


Figure 1-7. LAU-7/A Series Guided Missile Launcher

CMS control display unit via the WPNS key. Only those stores listed in this tactical manual are authorized to be carried and released or fired within the specified limits.

1.4.1 Sponson Guns. Two M60C 7.62-mm machineguns are integrally installed in each sponson. The M60C is an electrically charged, gas-operated weapon that was adapted from the M60 NATO automatic rifle. Each pair of guns (left and right) may be charged separately on the ground or in flight through the CMS Internal Guns page selected READY/SAFE and will be displayed on annunciator line (Figure 1-11). Ground use of the sponson-mounted charging switches requires application of external power so that the BATTERY switch be placed to ON to energize the primary dc bus; the MASTER ARM switch must be moved to ON.

1.4.2 Bombing Equipment. A variety of conventional weapons may be carried on five external store stations. Two pylons may be installed on each sponson and one pylon may be installed at centerline on the fuselage. The centerline station will carry a single store weighing up to 1,200 pounds at design g-loading and may be adapted for stores requiring 30-inch suspension spacing. The remaining stations are designed for 14-inch suspension spacing and will carry stores weighing up to 600 pounds at design g-loading. The external store station pylons are bolted on and cannot be dropped.

1.4.2.1 Optical Sight and Sight Controls. An illuminating, reflecting, noncomputing optical sight (Figure 1-9) is installed in the pilot's cockpit. The reticle may be depressed up to 270 mils through tilting of the reflecting glass to provide proper sight angles for release of weapons. The reticle image consists of a 2-mil pipper and quadrantal markings at 25 and 50 mils. A slip indicator is mounted above the mil-depression knob.

1.4.2.1.1 Inclinometer Light. A postlight, mounted on the optical sight inclinometer, provides approved illumination of the mil-setting index and the slip indicator. This light is controlled by the STBY COMPASS switch and intensity is controlled by the INSTRUMENTS rheostat (Figure 1-4).

1.4.2.1.2 Sight Reticle Brightness Knob. The sight reticle brightness knob (Figure 1-9) allows selection of sight reticle illumination and brightness.

1.4.2.1.3 Filament Select (FIL SEL) Switch. The FIL SEL switch (Figure 1-9) allows selection of the NO. 1 or NO. 2 sight reticle illuminator filament when the monitor dc bus is powered.

Note

Select NO. 1 filament to prevent top filament, if burned out, from shorting out bottom filament. To prolong filament life, the brightness knob should be kept at full low until brightness is required. Use NO. 2 filament after failure of NO. 1 filament.

Characteristics	
Rack Suspension Requirements (Inches)	14 or 30
Store Suspension Provisions	Single
Length (Inches)	65.12
Width (Inches)	21.6
Height (Inches)	14.2
Weight (Pounds)	87
Explosive Components	None

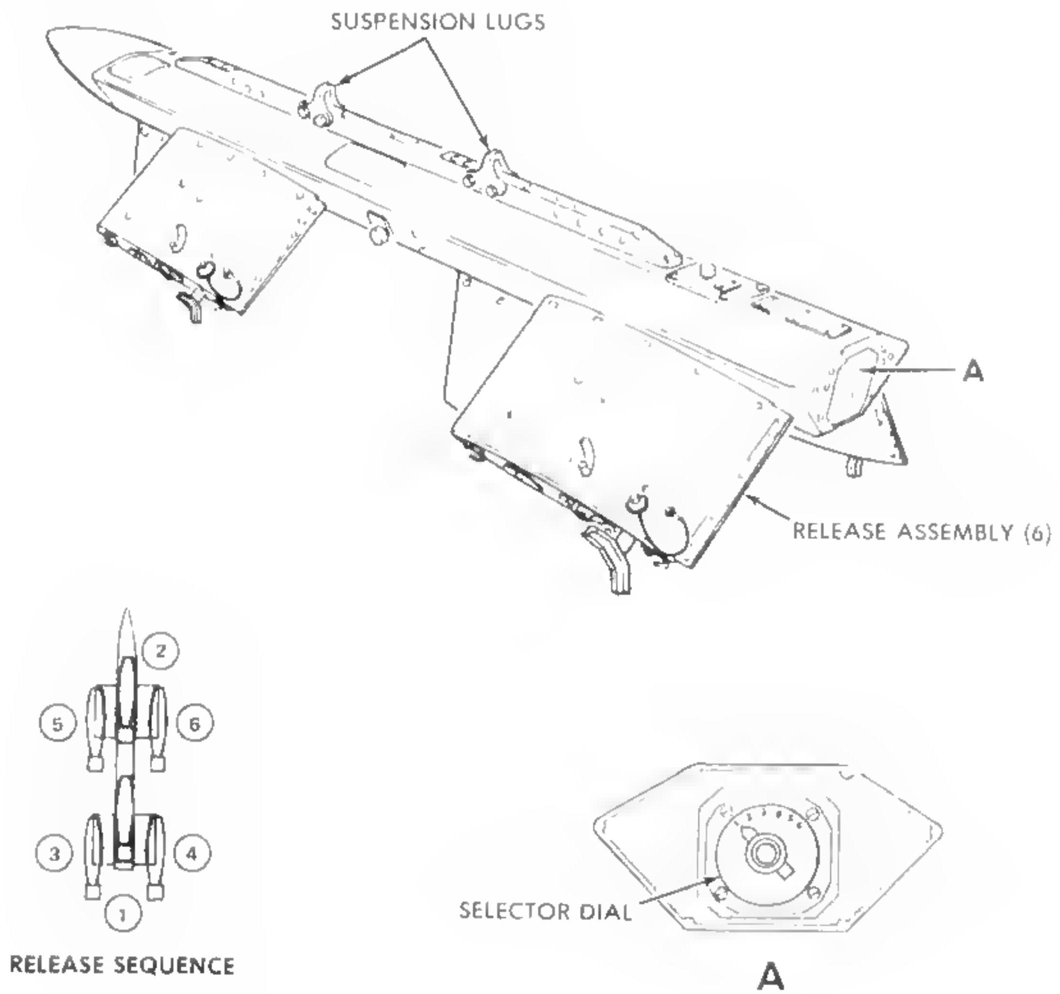


Figure 1-8. PMBR Rack

1.4.2.2 MASTER ARM Switch. The ON position of the MASTER ARM switch (Figure 1-9) applies power to the armament bus when the landing gear handle is in the UP position and the monitor dc bus is powered. All armament selection, release, and firing power is provided through the master arm circuit. The ARMT SAFETY DISABLE switch in the left main landing gear well bypasses the landing gear handle safety switch allowing the armament bus to be powered for ground checks and maintenance.

1.4.2.3 Drop Button. The drop button is located on the pilot's stick grip. This button is used to drop any bomb rack mounted store selected on the CMS Weapons Select pages and for selective stores jettison via the CMS (Figure 1-9).

1.4.2.4 Fire Trigger. The fire trigger is used to fire any internally or externally carried, forward-firing ordnance as selected on the CMS Weapons Select pages and to drop flares when the SUU-44A dispenser is installed (Figure 1-9).

1.4.2.5 Stores Emergency Release (STORES EMER REL) Button. The STORES EMER REL button (Figure 1-9), when depressed, releases all external stores. The store emergency release system, powered by the battery bus, is deactivated by the ground safety switch with weight on the gear and is operative only with the aircraft airborne. The emergency release system is independent of the MASTER ARM switch.

1.4.2.6 Emergency Stores Jettison (EMER ST JETT) Handle. The EMER ST JETT handle (Figure 1-9) is located on the left side of the pilot's center pedestal. Stores on stations 1, 2, 4, and 5 may be jettisoned manually by pulling this handle outward approximately 3 inches.

1.4.2.7 Missile Monitor Control. The 1200-Hz AIM-9 missile audio tone may be monitored by pulling up and turning the MSL monitor control to midrange. The control is located on the ICS monitor panel. Clockwise rotation will increase the audio level and counterclockwise rotation will decrease the audio level. Activation of the tone indicates the missile has acquired and locked onto an IR target. The tone will be heard in the crew's headsets until the missile is fired or the target is lost.

1.4.3 CMS Control and Display for Weapon Equipment. The CMS system provides an operator interface for weapon station selection, bomb arming and drop, internal gun firing, rocket and flare firing, and selective store jettisoning. Control and display of weapons status is selected by pressing the WPNS key on either CMS-CDU. Upon initial display of the Weapons Select pages, all weapon stations will be OFF, bombs will indicate SAFE, and GPU-2 gun rate of fire will be HIGH. If GPU-2 or bombs are not mounted, the functions will be disabled. Any station selected for drop or fire on the Weapons Select pages will be displayed on the annunciator line as a station select annunciator on all CMS pages until deselected. The flightcrew must ensure that the store configurations match the CMS display information; the CMS does not have the capability to cross-check for unauthorized store configurations (Figure 1-10).

1.4.3.1 CMS Power Control ON/OFF Switch. The CMS PWR switch, located on the CMS AND RADIO PWR CONTROL panel, provides electrical power to the CMS system for weapon control and display operation.

1.4.3.2 Weapons Select Pages. Two Weapons Select pages display the current aircraft weapon configuration for the left and right wing stations and store stations 1 through 5. Options on these pages allow the crew to review weapons configuration, select stores for drop or firing, select gun fire rate, or the arming of bombs. Access to the jettison and internal gun pages is also provided. Weapons loaded on store stations will be identified by mnemonics. See Figure 1-10 for mnemonic, store-type, station mode, and arming function. See Figure 1-11 for page description.

1.4.3.3 Weapons Configuration Pages. Aircraft weapon load information is programmed for display on the Weapons Select pages by the aircrew or ground personnel by using the Weapons Configuration page and associated Bomb, Missile, Rocket, PMBR, and Special Configuration List pages. When the landing gear is down, these pages may be accessed and weapon information inserted by pressing UP on the slew switch when viewing Weapons Select page 2/2. Rotary operation of LS1 on the Weapons Configuration page will sequentially display the desired store station (L, 1, 2, 3, 4, 5, or R) and its present load. The present store station load may be changed by selecting the desired Weapons Configuration List page from the options displayed (LS2 through LS8). On the Weapons Configuration List pages, LS key action will insert weapon choice from the list to the selected store station. When the desired weapon choice has been inserted, it will be displayed on the Weapons Select pages and the Weapons Configuration page (when selected) for the applicable store station. Auxiliary fuel and GPU-2 gun pod store station configurations can be entered directly from the Weapons Configuration page. See Figure 1-11 for detailed CDU key operation.

1.4.3.4 Jettison Page. The pilot may select the Jettison page (from the Weapons Select page 1/2) when he

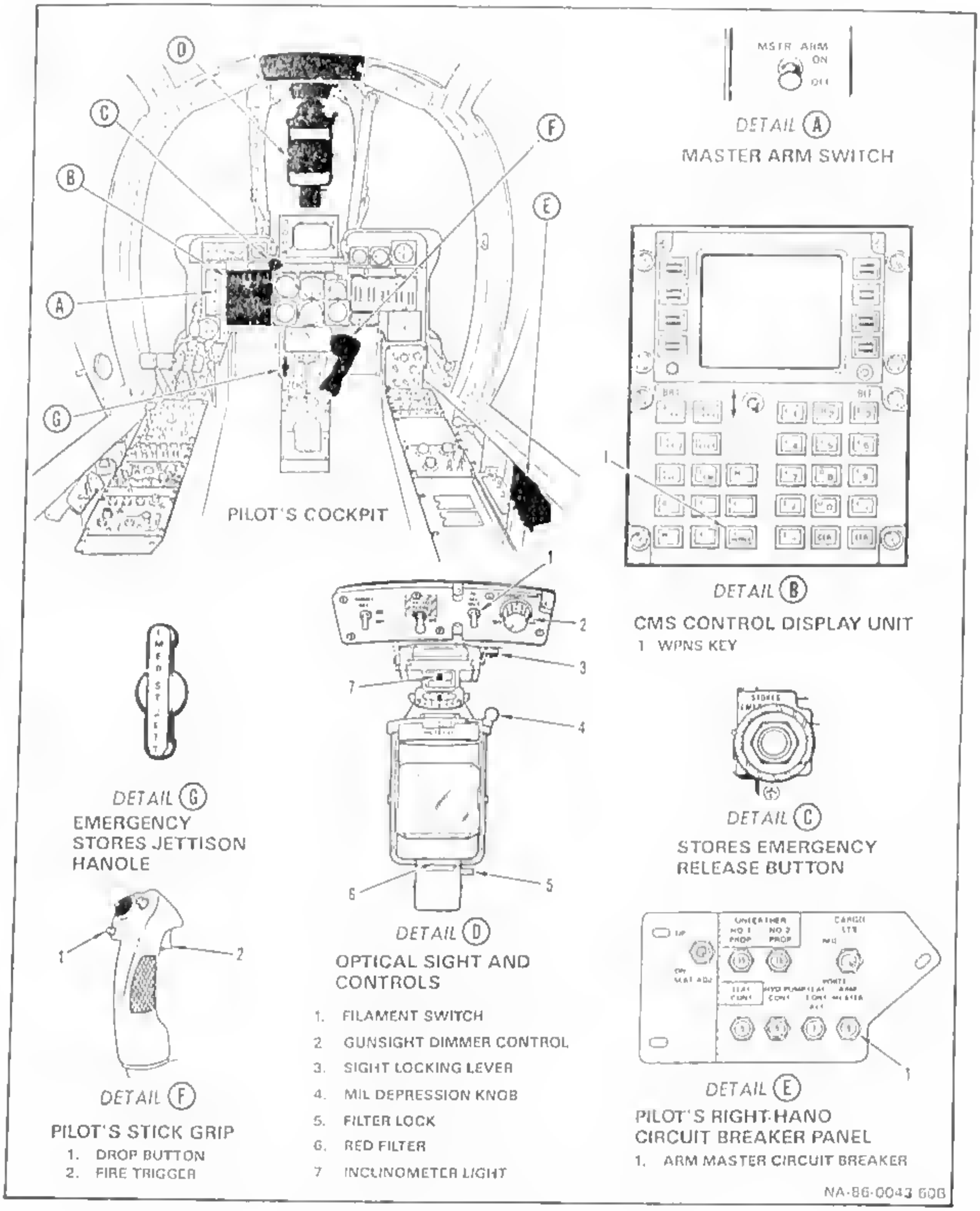
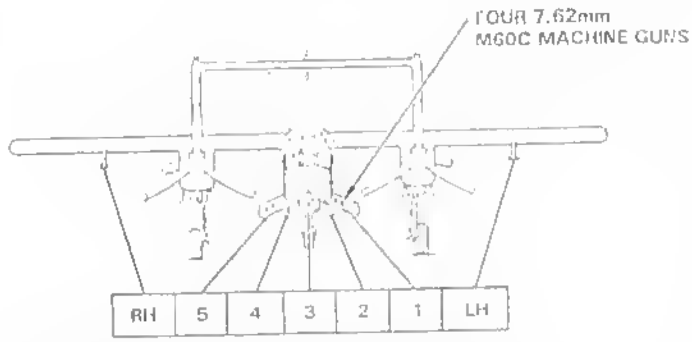


Figure 1-9. Optical Sight and Armament Controls



STORE NAME/TYPE	MNEMONIC	STATION MODE FIRE	DROP	ARMING N & T	FUNCTION TAIL	SEE NOTE
MK 81 GP BOMB	MK 81		X	X	X	2
MK 82 GP BOMB	MK 82		X	X	X	2
MK 83 GP BOMB	MK 83		X	X	X	3
MK 77 FIRE BOMB	FIRE		X	X	X	2
CBU-55 FAE BOMB	FAE		X	X		2
SIDEWINDER MISSILE	AIM-9	X				4
2.75 ROCKETS	2.75	X				5
5.0 ROCKETS	ZUNI	X				5
FUEL TANKS	FUEL					6
GPU-2 GUN POD	GPU-2	X				7
PMBR—PRACTICE BOMBS	MBRPB		X			8
PMBR—ADSID-III	MBRAD		X			8
SUU-25F/A FLARES	FL-25	X				2
SUU-44/A FLARES	FL-44	X				9
SUU-44	ASDTS		X			10
CAPTIVE SIDEWINDER	AIMTR	X				11
TELEMETRY POD	ACMR	X				11

NOTE

1. IT IS THE CREWS RESPONSIBILITY TO CROSS CHECK FOR CONFIGURATION
2. STATIONS 1 THROUGH 5 ONLY
3. STATION 3 ONLY
4. LEFT WING AND RIGHT WING ONLY–NO JETTISON FUNCTION
5. ALL STATIONS EXCEPT 3
6. STATION 3, LEFT WING AND RIGHT WING ONLY
7. RATE OF FIRE AND GUN CLEAR (STATIONS 2 AND/OR 4)
8. NO ARMING FUNCTION FOR MULTIPLE BOMB RACKS
9. LEFT WING AND RIGHT WING ONLY
10. STATIONS 1, 2, 4, AND 5 ONLY
11. LEFT AND RIGHT WING ONLY–NOT FIRED OR DROPPED. WITH THIS COMBINATION ON LEFT AND RIGHT WING STATIONS THE SIDEWINDER INTERLOCK WILL BE DISABLED.

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Figure 1-10. Selected Stores and Store Stations

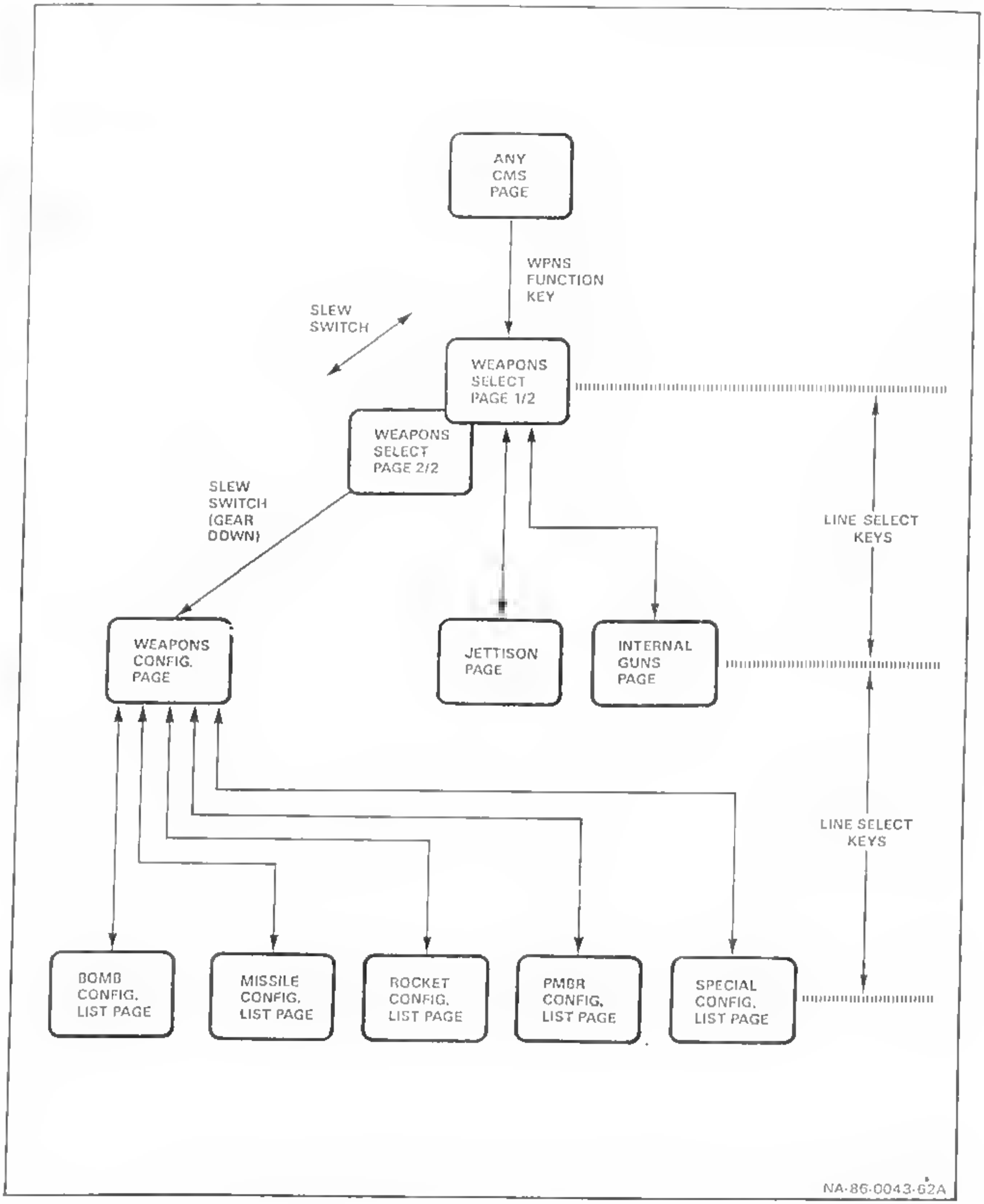
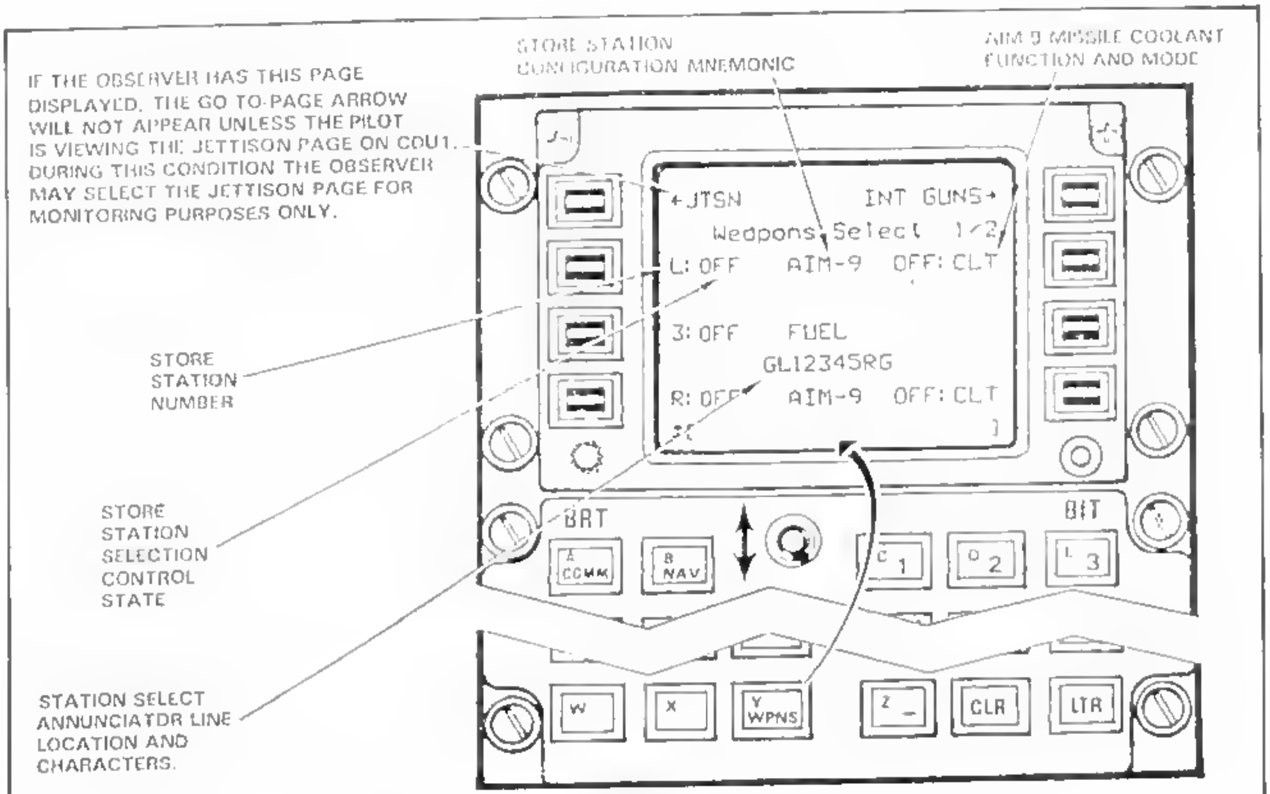


Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 1 of 11)



WEAPONS SELECT PAGE 1/2

LS1: GO TO THE JETTISON PAGE.

LS2: LEFT WING STORE STATION CONFIGURATION AND SELECTION CONTROL (OFF/FIRE OR OFF/DROP)

LS3: STORE STATION 3 CONFIGURATION AND SELECTION CONTROL (OFF/DROP, OFF/FIRE OR OFF/HI/LOW WITH GPU-2/A CONFIGURED).

LS4: RIGHT WING STORE STATION CONFIGURATION AND SELECTION CONTROL (OFF/FIRE OR OFF/DROP).

LS5: GO TO THE INTERNAL GUNS PAGE.

LS6: BOMB ARMING FUNCTION FOR THE LEFT WING STORE STATION.

(A) IF STATION SELECTED AND BOMB CONFIGURED ARMING OPTIONS ARE

SAFE = NOT ARMED
TAIL = TAIL ARMING
N + T = NOSE AND TAIL ARMING

(B) IF STATION SELECTED AND AIM-9 MISSILE CONFIGURED; COOLANT CONTROL (ON/OFF) IS DISPLAYED

LS7. BOMB ARMING FUNCTION FOR STORE STATION 3 (SEE LS6, PART A) OR GUN CLEAR MOMENTARY FUNCTION (ON/OFF).

NOTE

GUN RATE OF FIRE (LS3) AND GUN CLEAR FUNCTION (LS7) ARE NOT USED. GPU-2/A GUN POD IS NOT AUTHORIZED FOR STORE STATION 3.

LS8: BOMB ARMING FUNCTION FOR THE RIGHT WING STORE STATION (SEE LS6, PART A AND B).

SLEW UP/DOWN–GO TO THE WEAPONS SELECT PAGE 2/2.

NOTE

- STORE STATIONS THAT HAVE FUEL CONFIGURED (L,3,R) WILL HAVE NO WEAPONS STATION SELECT FUNCTION EXCEPT FOR JETTISON (FROM JTSN PAGE).
- WHEN AIM-9 IS CONFIGURED THE COOLANT CONTROL FUNCTION SHALL PROVIDE BOTH MISSILES WITH COOLANT, THEREFORE, SELECTION OF EITHER TURNS BOTH ON OR OFF.
- OFF/FIRE WILL BE DISPLAYED FOR FORWARD FIRING WEAPONS (MISSILES, ROCKETS, AND FLARES) OFF/DROP WILL BE DISPLAYED FOR GRAVITY WEAPONS (BOMBS, PMBR, ORDNANCE AND DETECTORS)

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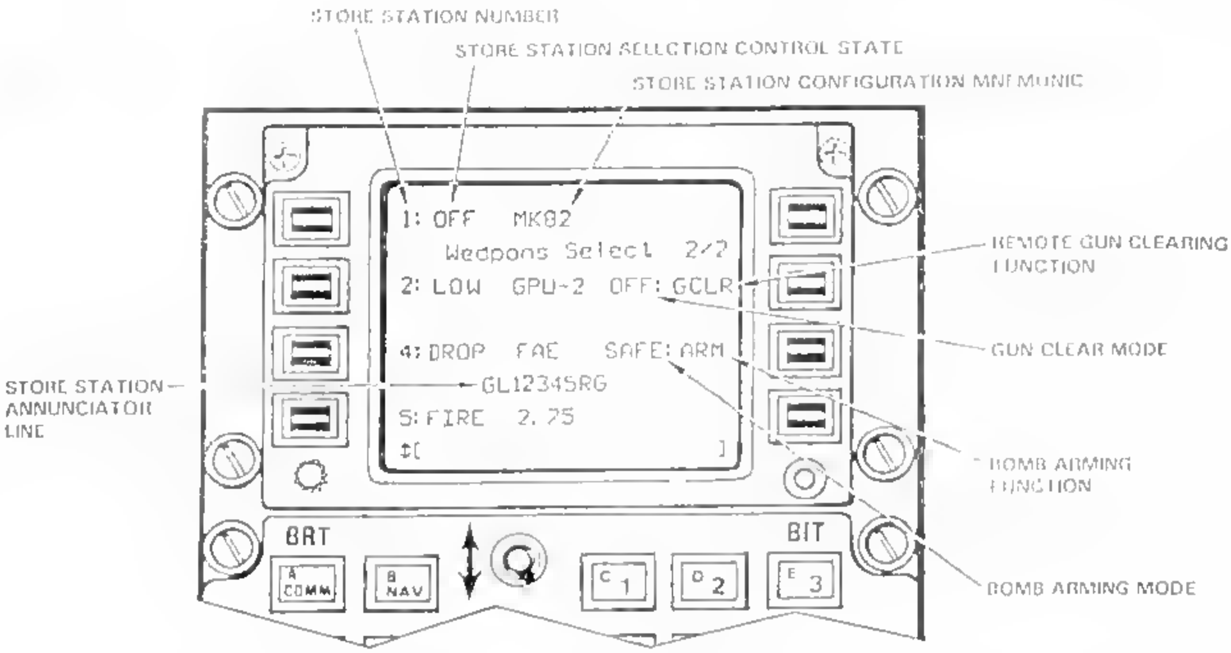
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 2 of 11)



WEAPONS SELECT PAGE 2/2

LS1: STORE STATION 1 CONFIGURATION AND SELECTION CONTROL (OFF/DROP OR OFF/FIRE)

LS2: STORE STATION 2 CONFIGURATION AND SELECTION CONTROL (OFF/DROP, OFF/FIRE OR OFF/HI/LOW WITH GPU-2/A CONFIGURED).

LS3: STORE STATION 4 CONFIGURATION AND SELECTION CONTROL (OFF/DROP, OFF/FIRE OR OFF/HI/LOW WITH GPU-2/A CONFIGURED).

LS4: STORE STATION 5 CONFIGURATION AND SELECTION CONTROL (OFF/DROP OR OFF/FIRE).

LS5: BOMB ARMING FUNCTION FOR STORE STATION 1, IF STATION SELECTED FOR DROP AND BOMB CONFIGURED:

SAFE = NOT ARMED
TAIL = TAIL ARMING
N + T = NOSE AND TAIL ARMING

LS6: BOMB ARMING FUNCTION FOR STORE STATION 2. SEE LS5 AND NOTE.

LS7: BOMB ARMING FUNCTION FOR STORE STATION 4. SEE LS5 AND NOTE.

LS8: BOMB ARMING FUNCTION FOR STORE STATION 5. SEE LS5.

SLEW UP/DOWN - GO TO THE WEAPONS SELECT PAGE 1/2. (WITH LANDING GEAR DOWN, SLEW UP WILL GO TO THE WEAPONS CONFIGURATION PAGE FROM 2/2).

NOTE

- THE BOMB ARMING FUNCTION WILL NOT BE DISPLAYED UNTIL THE CORRESPONDING WEAPON STATION IS SELECTED FOR DROP.
- STATIONS 2 AND 4 MAY CARRY THE GPU-2/A GUN POD. STATION SELECT SELECTION CONTROL (LS2 OR LS3) SHALL TOGGLE OFF, HI OR LOW AND THE OPPOSITE LINE SELECT KEYS (LS6 OR LS7) SHALL PROVIDE THE REMOTE CLEARING FUNCTION (ON/OFF: GLCR).
- ONLY LOW RATE OF FIRE IS AUTHORIZED FOR GPU-2/A GUN POD WITHOUT AAC 716.
- OFF/FIRE WILL BE DISPLAYED FOR FORWARD FIRING WEAPONS (ROCKETS, MISSILES AND FLARES). OFF/DROP WILL BE DISPLAYED FOR GRAVITY WEAPONS (BOMBS, PMBR ORDNANCE, AND DETECTORS).

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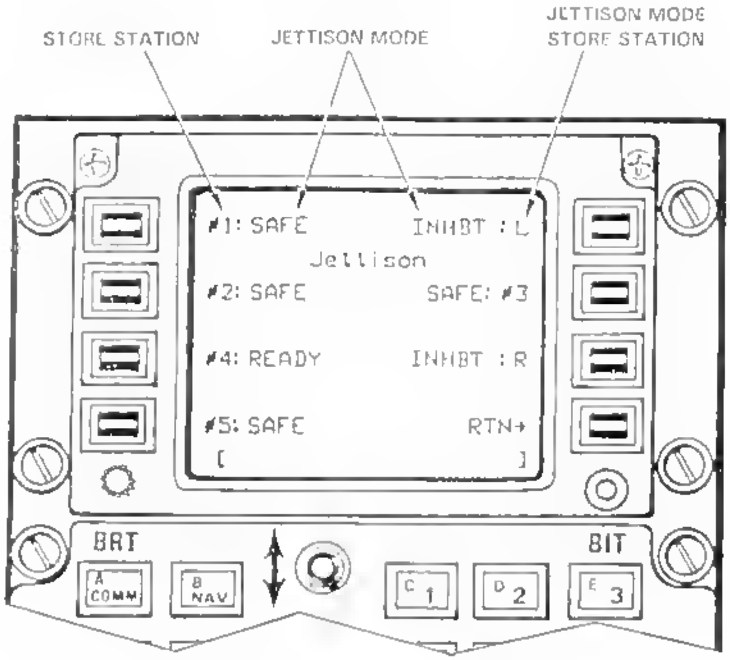
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 3 of 11)



JETTISON PAGE

LS1: TOGGLE STATION 1 JETTISON MODE (SAFE, READY, INHBT).

LS2: TOGGLE STATION 2 JETTISON MODE (SAFE, READY, INHBT).

LS3: TOGGLE STATION 4 JETTISON MODE (SAFE, READY, INHBT).

LS4: TOGGLE STATION 5 JETTISON MODE (SAFE, READY, INHBT).

LS5: TOGGLE STATION 3 JETTISON MODE (SAFE, READY, INHBT).

LS6: TOGGLE LEFT WING STATION JETTISON MODE (SAFE, READY, INHBT).

LS7: TOGGLE RIGHT WING STATION JETTISON MODE (SAFE, READY, INHBT).

LS8: RETURN TO THE WEAPON SELECT PAGE 1/2.

NOTE

- THIS SCREEN MAY ONLY BE USED ON THE PILOT'S CDU. OBSERVER MAY ONLY VIEW IT WHEN THE PILOT HAS IT DISPLAYED ON CDU 1.
- STATIONS CONFIGURED WITH AIM-9 MISSILES OR PMBR ORDNANCE WILL DISPLAY (INHBT). INHIBITED FOR JETTISON.
- AFTER STORE STATIONS ARE SELECTED TO "READY". PUSHING THE DROP BUTTON ON THE PILOT'S CONTROL STICK GRIP WILL JETTISON SELECTED STORE.
- ARMING AND FIRE/DROP FUNCTIONS ARE DISABLED WHEN THIS SCREEN IS DISPLAYED. UPON EXITING THIS SCREEN THE PREVIOUS WEAPON ARMING CONDITION WILL BE RESTORED

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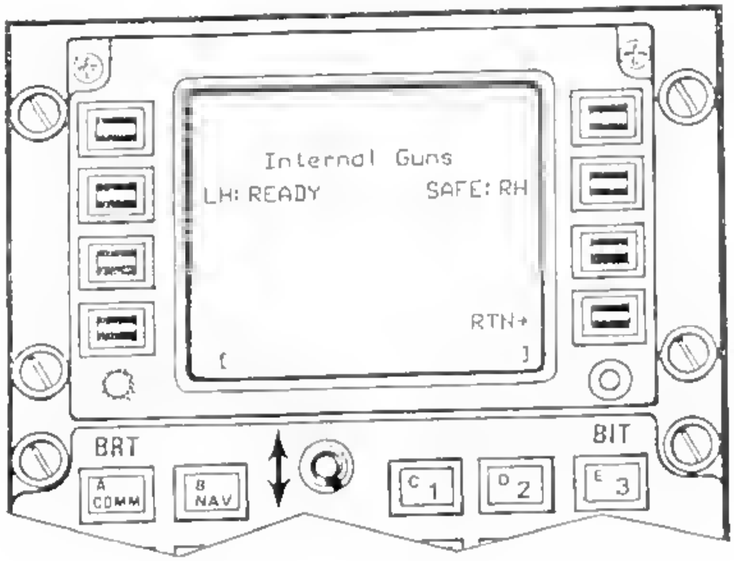
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 4 of 11)



INTERNAL GUNS PAGE

LS1- NO ACTION.

LS2- TOGGLE LEFT INTERNAL GUN MODE (SAFE/READY).

LS3- NO ACTION.

LS4- NO ACTION.

LS5- NO ACTION.

LS6- TOGGLE RIGHT INTERNAL GUN MODE (SAFE/READY)

LS7- NO ACTION.

LS8- RETURN TO THE WEAPONS SELECT PAGE 1/2.

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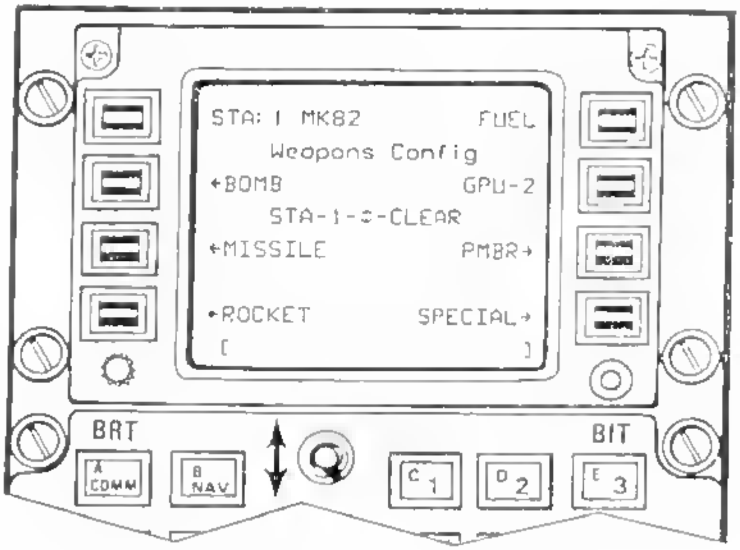
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 5 of 11)



* WEAPONS CONFIGURATIONS PAGE

LS1-SEQUENCES THROUGH STATION LOCATIONS (L, 1, 2, 3, 4, 5, R), OR THE STATION CAN BE ENTERED VIA THE SCRATCH PAD. DISPLAYS DASHES IF NO WEAPON LOADED.

LS2-GO TO THE BOMB CONFIGURATION LIST PAGE.

LS3-GO TO THE MISSILE CONFIGURATION LIST PAGE.

LS4-GO TO THE ROCKET CONFIGURATION LIST PAGE.

LS5-CONFIGURE AUXILIARY FUEL TANK AT CURRENT STATION (FUEL).

LS6-CONFIGURE GUN POD AT CURRENT STATION (GPU 2/A).

LS7-GO TO THE PMBR CONFIGURATION LIST PAGE.

LS8-GO TO THE SPECIAL CONFIGURATION LIST PAGE

SLEW UP/DOWN-CLEARS CURRENT STATION.

* ACCESSIBLE ONLY WHEN GEAR DOWN.

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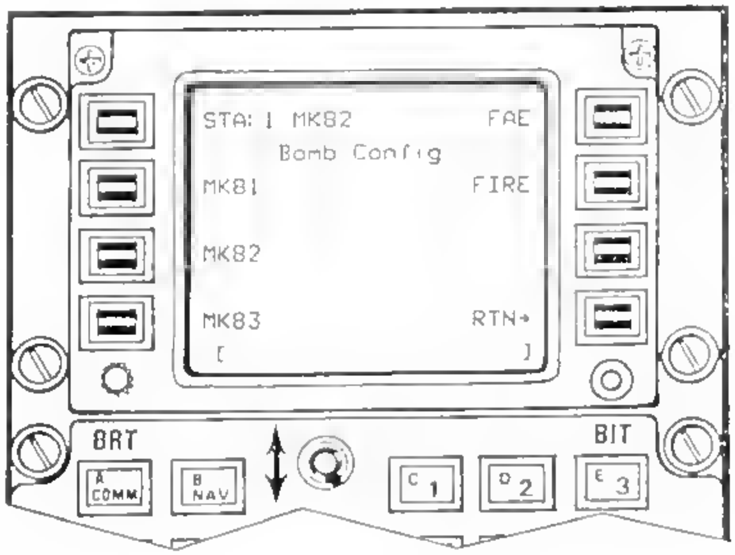
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 6 of 11)



BOMB CONFIGURATION LIST PAGE

LS1 – SEQUENCES THROUGH STATION LOCATIONS (L, 1, 2, 3, 4, 5, R), OR THE STATION CAN BE ENTERED VIA THE SCRATCH PAD.

LS2 – CONFIGURE A MK 81 BOMB AT THE CURRENT STATION.

LS3 – CONFIGURE A MK 82 BOMB AT THE CURRENT STATION.

LS4 – CONFIGURE A MK 83 BOMB AT THE CURRENT STATION.

LS5 – CONFIGURE A FAE BOMB AT THE CURRENT STATION.

LS6 – CONFIGURE A FIRE BOMB AT THE CURRENT STATION.

LS7 – NO ACTION.

LS8 – RETURN TO THE WEAPONS CONFIGURATION PAGE.

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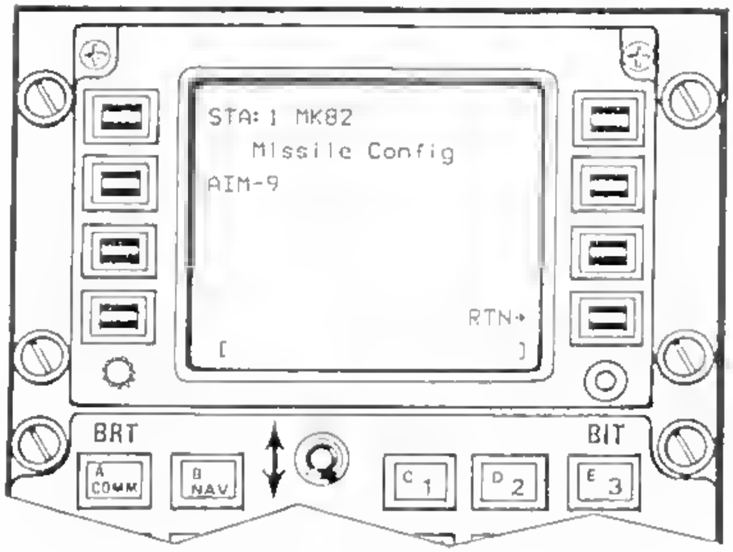
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 7 of 11)



MISSILE CONFIGURATION LIST PAGE

LS1 SEQUENCES THROUGH STATION LOCATIONS (L, 1, 2, 3, 4, 5, R), OR THE STATION CAN BE ENTERED VIA THE SCRATCH PAD.

LS2 — CONFIGURE AN AIM-9 MISSILE AT THE CURRENT STATION.

LS3 — NO ACTION.

LS4 — NO ACTION.

LS5 — NO ACTION.

LS6 — NO ACTION.

LS7 — NO ACTION.

LS8 — RETURN TO THE WEAPONS CONFIGURATION PAGE.

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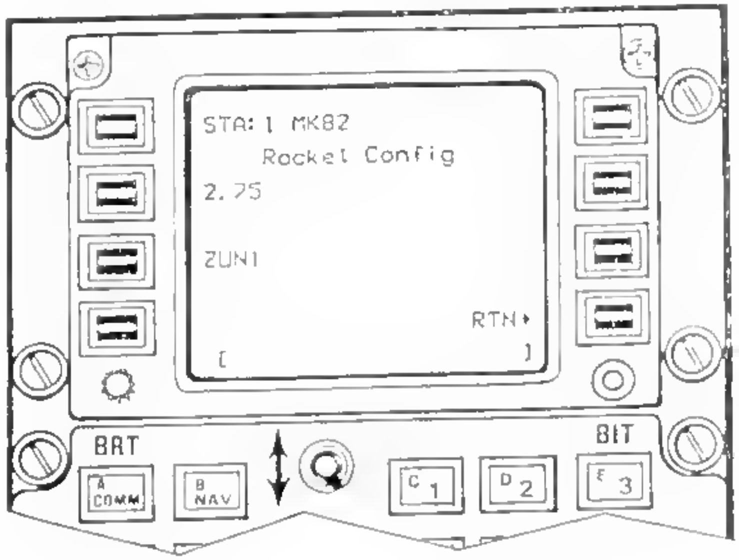
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 8 of 11)



ROCKET CONFIGURATION LIST PAGE

LS1 – SEQUENCES THROUGH STATION LOCATIONS (L, 1, 2, 3, 4, 5, R), OR THE STATION CAN BE ENTERED VIA THE SCRATCH PAD.

LS2 – CONFIGURE A 2.75 ROCKET AT THE CURRENT STATION.

LS3 – CONFIGURE A ZUNI ROCKET AT THE CURRENT STATION.

LS4 – NO ACTION.

LS5 – NO ACTION.

LS6 – NO ACTION.

LS7 – NO ACTION.

LS8 – RETURN TO THE WEAPONS CONFIGURATION PAGE.

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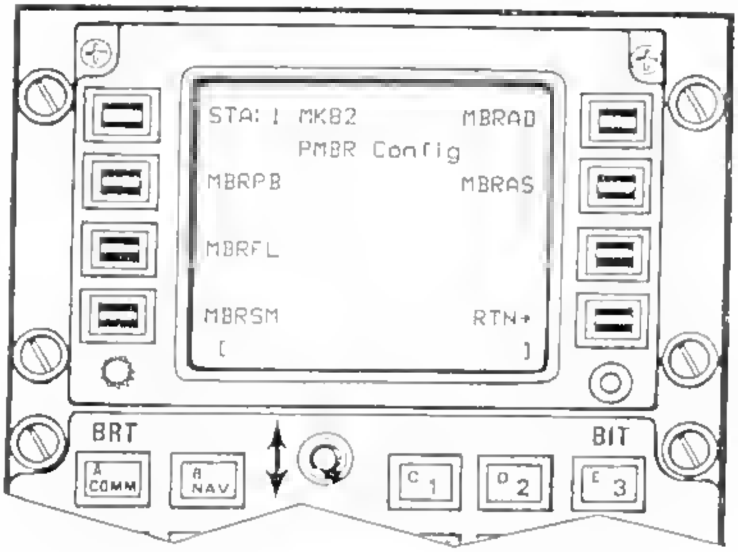
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 9 of 11)



PMBR CONFIGURATION LIST PAGE

LS1 – SEQUENCES THROUGH STATION LOCATIONS (L, 1, 2, 3, 4, 5, R), OR THE STATION CAN BE ENTERED VIA THE SCRATCH PAD.

LS2 – CONFIGURE A MBRPB PMBR AT THE CURRENT STATION.

LS3 – CONFIGURE A MBRFL PMBR AT THE CURRENT STATION.

LS4 – CONFIGURE MBRSM PMBR AT THE CURRENT STATION.

LS5 – CONFIGURE MBRAD PMBR AT THE CURRENT STATION.

LS6 – CONFIGURE MBRAS PMBR AT THE CURRENT STATION.

LS7 – NO ACTION.

LS8 – RETURN TO THE WEAPONS CONFIGURATION PAGE.

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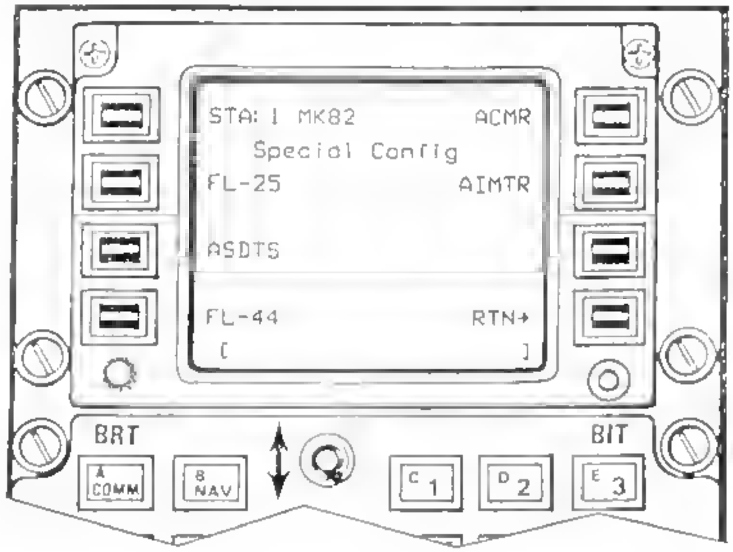
Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 10 of 11)



SPECIAL CONFIGURATION LIST PAGE

LS1: SEQUENCES THROUGH STATION LOCATIONS (L, 1, 2, 3, 4, 5, R), OR THE STATION CAN BE ENTERED VIA THE SCRATCH PAD.

LS2: CONFIGURE FL-25 (FLARES) AT THE CURRENT STATION.

LS3: CONFIGURE ASOTS (SUU-44) AT THE CURRENT STATION.

LS4: CONFIGURE FL-44 (FLARES) AT THE CURRENT STATION.

LS5: CONFIGURE ACMR (TELEMETRY POD) AT THE CURRENT STATION.

LS6: CONFIGURE AIMTR (CAPTIVE SIDEWINDER) AT THE CURRENT STATION.

LS7: NO ACTION.

LS8: RETURN TO THE WEAPONS CONFIGURATION PAGE.

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Figure 1-11. WPNS Key Flow Chart and Page Displays (Sheet 11 of 11)

desires to override the weapon delivery mode and selectively jettison the indicated stores. CMS-CDU programming will not permit the GPU-2/A gun pod to be jettisoned from stations 2 and 4 or PMBR ordnance from any station. The AIM-9 Sidewinder missile will also be inhibited from jettison. To jettison, the pilot must select READY with applicable LS key and push the drop button to release the selected store. Arming and firing functions are automatically disabled (safe) when the Jettison page is selected by the pilot. When the pilot exits the Jettison page, all stations return to their original state (prior to entry). The observer has access to this page for monitor purposes only. See Figure 1-11 for detailed operation.

1.4.3.5 Internal Guns Page. Arming of the left and right internal guns may be selected by selecting INT GUNS on the Weapons Select page 1/2 and selecting LS2 (left guns) and/or LS6 (right guns) on the Internal Guns page. The guns can be fired by pressing the fire trigger on the pilot's stick grip (Figure 1-9).

1.4.3.6 Station Select Annunciator Messages. These messages indicate which stations have been armed for use. Only stations selected (G, L, 1, 2, 3, 4, 5, R, and/or G) will be displayed. The remaining stations will be indicated by a dash (-). L and R represent the left and right wing stations respectively. The G preceding L represents the left internal guns and the G following R represents the right internal guns. The annunciator (GL 12345RG) is cleared when all stations have been deselected for firing or dropping.

CHAPTER 2

Weapons Ground Procedures

2.1 OPTICAL SIGHT CHECKS

Prior to each sortie, the operation and azimuth alignment of the optical sight should be checked.

1. With one generator on the line, check both filaments.

2. Move the sight depression lever from zero through 270 mils and back to zero, noting that the reticle moves smoothly and without slippage.

3. Prior to or during taxi, line up the aircraft pitot tube on any long, straight line, such as a taxi stripe. When the aircraft is pointed perfectly straight with no nosewheel cocking, the pipper should fall exactly on the pitot tube or the taxi stripe.

Note

Because of the design of the gunsight, the pilot cannot check for errors in elevation, other than slippage.

2.2 ARMAMENT SAFETY (STRAY VOLTAGE) CHECK

This check will be performed by ordnance personnel in a designated arming area prior to aircraft launch. No safety pins or checks should be pulled in the line area. Refer to the OV-10 Loading Manual for the standard arming and dearming signals.

1. Propellers — ZERO PITCH

2. MASTER ARM switch — OFF

3. ALE-39 POWER/FLARE SALVO switch — OFF

4. Radar altimeter — OFF

5. Internal guns — SAFE

6. Station mode select switch — OFF

7. AIM-9 missile select switch — OFF/ SAFE

8. IFF — STANDBY

9. Tacan — RECEIVE

10. Doppler NAV mode select switch — AD

11. ICS — HOT MIKE (as desired)

12. Anticollision light — OFF

WARNING

Absolutely no transmissions are to be made while any member of a flight is arming.

13. Both hands for both crewman — RAISED, AWAY FROM ALL COCKPIT SWITCHES.

2.3 POSTARMING CHECKLIST

1. Anticollision light — ON

2. Tacan — T/R

3. Radar altimeter — ON

4. IFF — STBY.

CHAPTER 3

Weapon Delivery Maneuvers

3.1 DELIVERY FACTORS

The basic conventional ordnance delivery maneuvers for the OV-10 are medium- and slow-speed dives, level releases, pop-up, and loft. Factors affecting delivery accuracy are airspeed, dive/loft angle, release height, coordinated flight, aircraft flightpath (g loading), gross weight, distance from target for loft, and wind or target motion (Figure 3-1). Examples of impact errors due to deviation from intended release conditions (release error sensitivities) are shown in NWP 55-6-OV10A/D Vol. I.1. Weapon delivery sight angle charts are also presented in NWP 55-6-OV10A/D Vol. I.1.

3.2 DIVE DELIVERY

The common dive delivery angles are 10°, 20°, 30°, 45°, and infrequently, 60°. The most common for the OV-10 is the 30° dive. For dive angles, corresponding release altitude blocks, and the ordnance normally associated with each delivery maneuver refer to the information in Figure 3-2. Advantages and disadvantages are also listed. Each dive angle, altitude block, and weapon combination is based on obtaining maximum delivery accuracy and the most effective impact pattern. The bottom of the release altitude block is based on safety from weapon fragmentation or adequate terrain clearance.

CAUTION

More than one type of ordnance is presented for each release altitude block. The altitude for the ordnance type is shown adjacent to the particular weapon and applies only to that weapon.

A dive bombing run consists of four phases: entry, tracking, release, and recovery. A dive with release airspeeds between 220 and 250 knots is considered to be within the normal speed range. The optimum speed dive normally utilizes 240 KTAS as the release airspeed. The sight angle charts in Volume I.1, Chapter 4 contain information for dives up to 45°, with airspeeds from 150 to 250 knots.

3.2.1 Entry Options. The three basic entry options for dive bombing are diving entry, level entry, and pop-up entry. All armament switches except the MASTER ARM switch should be positioned and the gunsight adjusted prior to arriving at the entry point. Full attention can then be given to establishing a proper track. For all three entries, use of a base leg, offset 45° to 90° from the attack heading, facilitates target acquisition. Because of the unique characteristics of the pop-up entry, it is treated separately in paragraph 3.5.

3.2.2 Tracking. Tracking consists of acquiring the target (or aim point) in the gunsight and establishing a rate of movement of the pipper so that it is on target at the instant the aircraft arrives at the release altitude, on the dive angle, and with the airspeed for which the sight setting was computed. Airspeed and dive angle control are achieved with relatively less trouble than it would be to solve the problem of tracking to the release point. Tracking can be accomplished by placing the pipper on the target immediately after dive entry (curvilinear), placing the pipper at the 6 o'clock position and allowing it to move to the target (straight path), or placing the pipper at 6 o'clock and pulling through the target with a constant 1g acceleration.

3.2.2.1 Curvilinear Path. When the gunsight pipper is held on the target during the dive, the aircraft flightpath becomes convex and the dive angle increases. The g load decreases as the dive progresses. Tracking is simplified, since the pipper is held on the target until weapon separation. However, there is a hazard of bomb-to-aircraft collision, and corrections during the run are difficult to apply.

3.2.2.2 Straight-Line Path. The aircraft follows a straight-line path during the dive, while the pipper moves forward as the altitude is decreased. The g-load factor becomes slightly less than 1g but still affords good bomb-to-aircraft separation. Although the pipper moves in relation to the target, the dive angle remains constant. Guidelines can be provided for pipper position control.

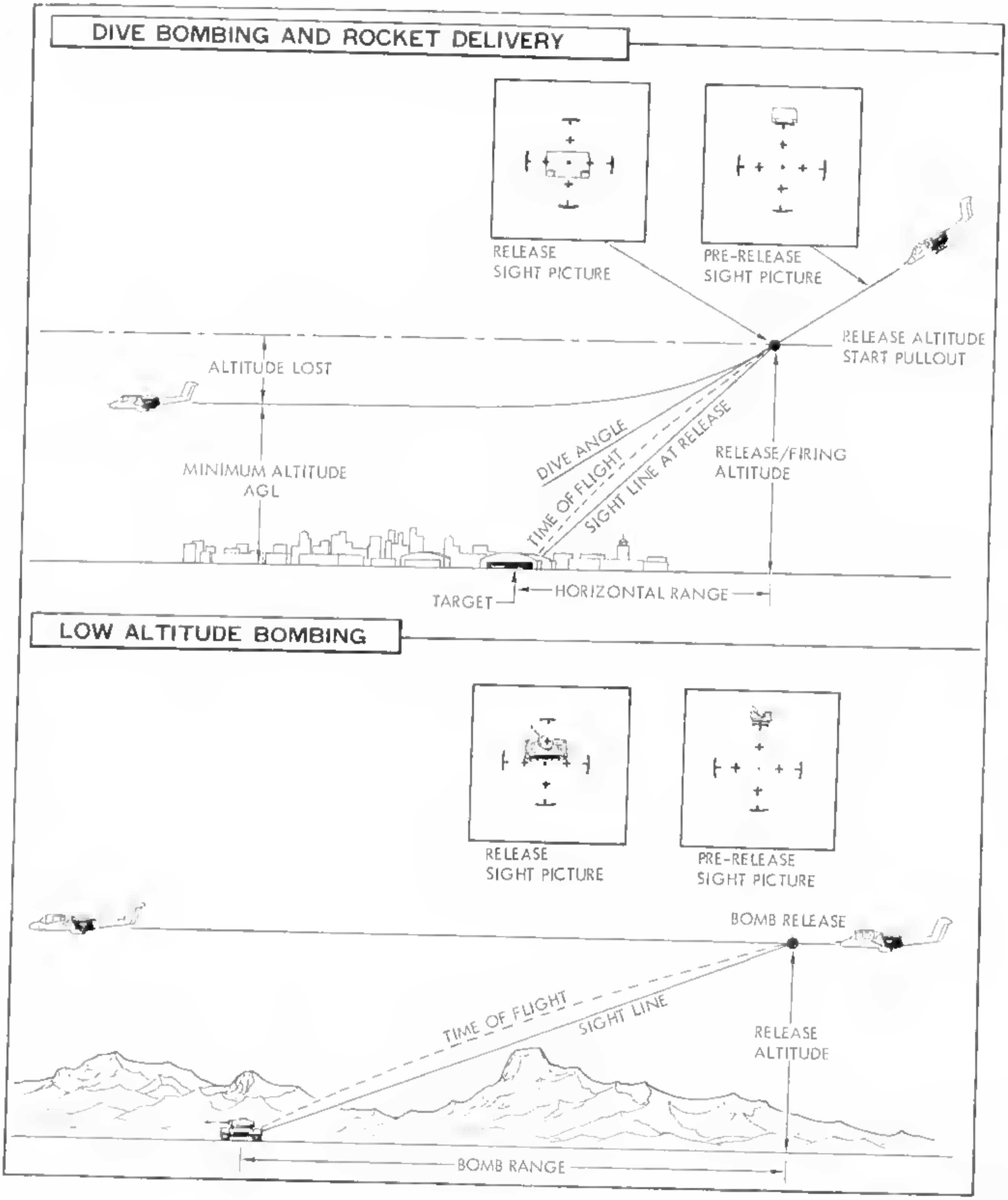


Figure 3-1. Air-to-Ground Attack (Sheet 1 of 2)

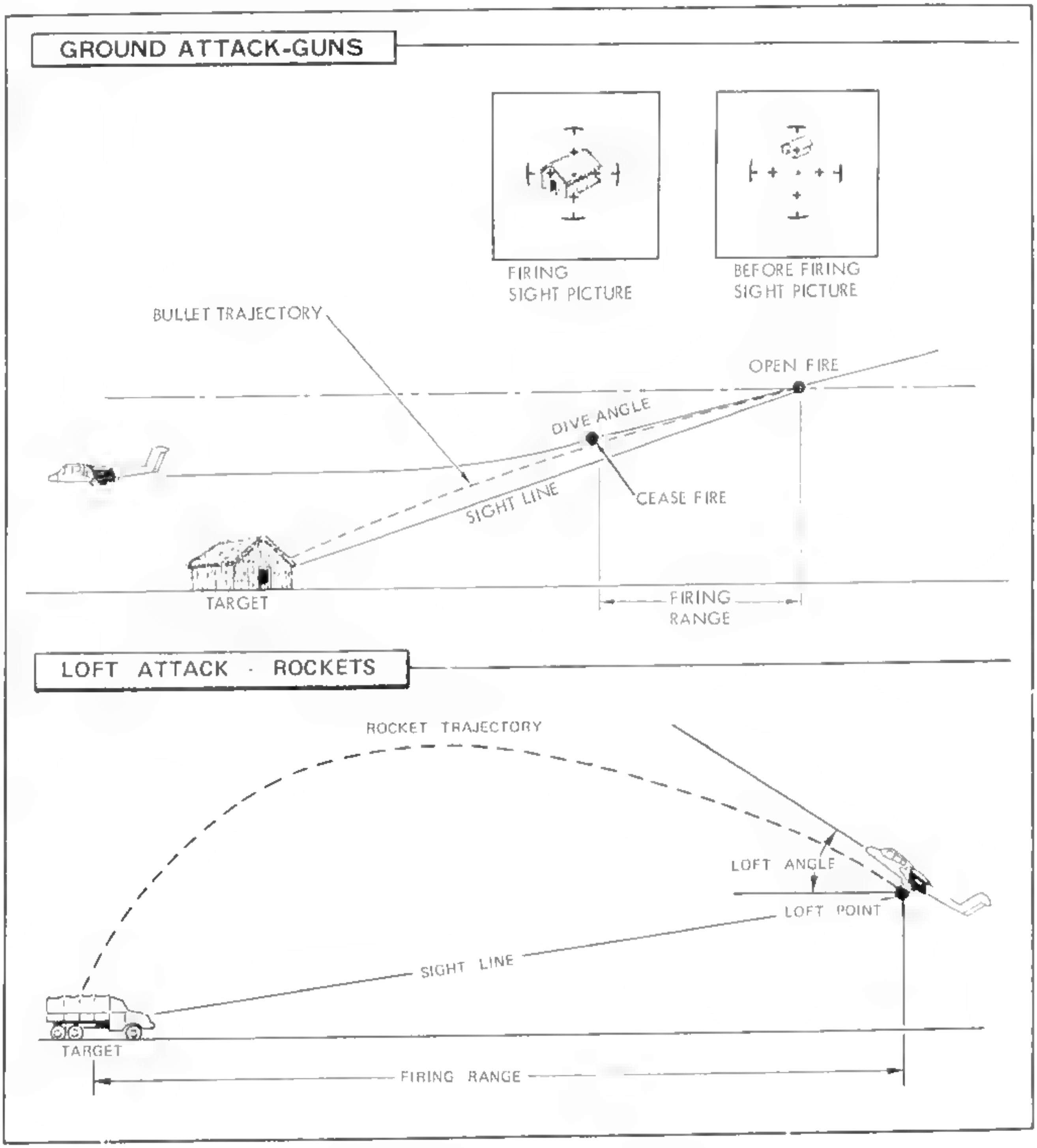


Figure 3-1. Air-to-Ground Attack (Sheet 2 of 2)

DIVE ANGLE (DEGREES)	RELEASE ALTITUDE (FEET AGL)	WEAPONS	ADVANTAGES	DISADVANTAGES
0	200 to 2500	CBU's, FIRE BOMBS, ROCKETS	1. SOME STANDOFF CAPABILITY FOR ROCKETS. 2. ALLOWS DELIVERY UNDER 1000- TO 1500-FOOT CEILING.	1. REDUCTION OF SURPRISE. 2. EXPOSURE TO SMALL ARMS/AAA. 3 POOR ACCURACY FOR ROCKETS (LONG RANGE).
10	400 to 600	CBU'S, FIRE BOMBS STRAFING	1 IMPROVED ACCURACY AS COMPARED TO LEVEL DELIVERY. BEST ACCURACY FOR FIRE BOMBS GOOD ACCURACY FOR STRAFING AND CBU'S	1 REDUCTION OF SURPRISE COMPARED TO LEVEL DELIVERY 2 EXPOSURE TO SMALL ARMS WEAPONS FIRE IN TARGET AREA.
	1000	ROCKETS	2 ALLOWS DELIVERY UNDER 1000 TO 1500 FOOT CEILING	3 POOR ACCURACY (LONG RANGE) FOR ROCKETS
20	800 to 1200 1000 to 1500 2000 to 2500	RETARDED BOMBS STRAFING ROCKETS, CBU'S, FIRE BOMBS	1 BEST ACCURACY FOR RETARDED BOMBS AND STRAFING. 2. ALLOWS ATTACK UNDER 2000 TO 3000 FOOT CEILING	1. EXPOSURE TO SMALL ARMS, AUTOMATIC WEAPONS FIRE, AND SHORT-RANGE SAM ENVELOPE. 2 REDUCED ACCURACY (LESS THAN 30 DEGREES) FOR UNRETARDED BOMBS AND ROCKETS.
30	2000 to 3500	ROCKETS, RETARDED BOMBS, STRAFING	1 BEST ACCURACY FOR BOMBS AND ROCKETS (2500- TO 3000 FOOT RELEASE ALTITUDE RANGE)	1. RELEASE ALTITUDE FOR BEST ACCURACY REQUIRES EXPOSURE TO AAA AND SAM FIRE (.50 CAL)
	1500 to 2500	20 MM STRAFING		
45	4000 to 5000	UNRETARDED BOMBS, ROCKETS, 20 MM	1 ACCURACY SUFFICIENT FOR USE AGAINST POINT TARGETS (UNRETARDED BOMBS AND ROCKETS). 2 ABOVE EFFECTIVE RANGE OF SMALL ARMS AND AUTOMATIC WEAPONS FIRE, MORE DIFFICULT FOR AAA OR OPTICAL AAA	1. INCREASES EXPOSURE TO SAM OR AAA TRACKING RADARS. 2 REDUCED ACCURACY COMPARED TO 30 DEGREES DELIVERY. 3 MORE DIFFICULT TRACKING FOR PILOT COMPARED TO LOWER DIVE ANGLES
45 to 60	10000 to 12000	ROCKETS	1. ACCURACY FOR MARKING POINT TARGET FOR CAS. 2. ABOVE EFFECTIVE SMALL ARMS, AAA, AND HAND HELD SAMS.	1. RAPID ALTITUDE LOSS. 2. TARGET ACQUISITION DIFFICULT.

Figure 3-2. Delivery Maneuver Selection

3.2.2.3 One-g Path. The pipper is initially placed at the 6-o'clock position and, as the release point is approached, 1g acceleration is applied causing the pipper to sweep through the aim point. A 1g load is greater than the g-load required for a straight-path dive; therefore, the flightpath is curved (concave) and the dive angle is continuously decreased during the dive. One g (or more) at bomb release provides the best bomb-to-aircraft separation. However, the constantly changing dive angle and the rapid pipper movement at release makes this an impractical method for accurate bombing.

3.2.2.4 Recommended Tracking Methods. The combination of curvilinear and straight-path dive tracking is recommended as the method that provides position checks and reduces the variables in the dive bombing run. The pipper is initially held at a fixed number of mils below the target. Then, at a predetermined altitude, the pipper is allowed to move toward the target so that a straight-line flightpath is achieved during the final tracking portion of the dive until release.

3.2.2.4.1 Pipper Position. Some rules of thumb for pipper position during a straight-path dive are as follows:

1. Pipper position should be two-thirds of the sight setting (mils) below the target at three times the release altitude (feet AGL).

2. Pipper should be one-half the sight setting below the target at two times the release altitude.

3. Pipper should be one-third the sight setting below the target at one and one-half times the release altitude.

The thumb rules are derived from the ratio of the pipper position (relative to the target) to the sight setting being equal to the ratio of the slant range to the target. By substituting altitude for slant range, the rules of thumb are apparent.

When using the curvilinear and straight-line methods in combination, place the pipper below the target one-third of the total mils of the sight setting for the anticipated release altitude and then hold this position until approximately one and one-half times the release altitude is approached. Then, allow the pipper to move toward the target to arrive on the target at release altitude. A minimum tracking time of 4 seconds should be provided.

3.2.2.4.2 Balanced Flight. In all aircraft ordnance deliveries, it is important to be in balanced flight. Whenever ordnance is released in a skid, the impact deflection error is in the direction of the skid. A freefall bomb will follow the flightpath. This is not true for forward firing ordnance. However, there will be an impact deflection error between the aircraft flightpath and the line of sight. This is the result of the gun or rocket initial velocity and the aircraft skidding velocity. The bullets will return toward the flightpath by approximately 20 percent of the skid angle.

3.2.2.4.3 Moving Target Correction. When attacking moving targets, lead for target motion is computed exactly as in wind corrections; a correction must be made to place the pipper ahead of the target. As an aid in positioning the pipper in such an attack, the proper lead in mils may be computed and the gunsight horizontal mil marks used for tracking with the proper lead. Another technique is the use of a rule of thumb which depends on selected firing parameters (or bullet time of flight) and target speed. The thumb rule dictates aiming ahead of the direction of movement of the target at a given value in feet multiplied by estimated speed of the target in miles per hour. These values are:

Dive Angle (Degrees)	Lead Distance (Feet) Per MPH of Target Speed
10	1.5
20, 30	4.5
45, 60	7.5

Note

The total lead distance is estimated in feet on the ground and is not a mil lead.

3.2.2.4.4 Wind Corrections. Firing in a wind presents a problem similar to that encountered in any other type of conventional weapon delivery; a correction must be made into the wind. The bullet fired in a wind will drift downwind a distance equal to the product of bullet time of flight times the windspeed. Since the bullet flight time is short, the windspeed correction is relatively small in comparison to that required for freefall bombs.

To arrive at the correct aiming point just before the aircraft reaches firing range, the aircraft is banked into the crosswind and the pipper is walked up to the target as in a zero wind attack. Although firing while the aircraft is in a bank will normally cause short impact errors in the direction of the bank, these errors will be small enough to be disregarded. The recommended technique is to determine the upwind aiming point and then solve the wind drift problem by banking the aircraft into the wind. The pilot should vary the bank angle as necessary until just before reaching the firing

range, after which a constant angle of bank should be maintained. Rudder pressure should be applied as necessary to maintain pipper position throughout the firing portion of the run. Care must be taken not to overcorrect with the rudders and *spray them around.* While firing in a bank, the pendulum effect on the sight angle depression required for guns is small; therefore, the pilot can easily correct for deflection tracking errors.

3.2.2.5 Weapon Release and Recovery. Weapon release should be accomplished with aircraft in a straight-line flightpath (constant dive angle) and coordinated flight. After weapon release, a 2g's to 3g's recovery should be initiated and full power applied once the nose of the aircraft is above the horizon. Once the nose reaches the horizon, appropriate evasive action should commence. High airspeed (minimum of 170 knots) should be maintained throughout the departure from the target area, if possible. High-g jinking above 3g's should normally be avoided in order to maintain maximum airspeed.

3.3 LEVEL DELIVERY

A high-speed, low-level maneuver is used for delivery of some CBUs, sensors, fire bombs, and retarded weapons (Figure 3-3). The advantages are the elements of surprise and the tracking problems presented to the enemy. The disadvantages of level delivery are exposure to small arms and automatic weapons fire, difficult target acquisition, and large release error sensitivities. In this description, level deliveries are considered to be low-altitude releases. Airspeed may be as high as 350 knots. Sight angles and airspeeds for specific weapons and deliveries are described in Chapter 4, Vol. I.I.

3.3.1 Level Entry. Target acquisition is difficult unless the target has a prominent feature in the immediate vicinity. If a higher approach altitude is required to facilitate target identification, a gliding or diving approach can be made and should be planned to arrive about 1,500 to 2,000 feet short of the release point with stabilized airspeed and altitude (Figure 3-3).

3.3.2 Level Tracking. Crab as necessary to maintain a straight flightpath toward the target. High drag stores such as CBU or fire bombs will require offset from the target to correct for deflection wind.

3.3.3 Level Weapon Release and Recovery. The relatively large release error sensitivities require that the altitude and airspeed be accurately held as programmed (Figure 3-3).

3.3.4 Level Delivery Considerations. Level delivery of rockets and guns offers some very positive advantages, but also has some corresponding disadvantages. The advantage of longer standoff ranges can be a very valuable asset. A long beaten zone against a linear target offers better coverage. On the other hand it is extremely difficult to judge range estimation to achieve proper firing parameters. Without a known point for trigger pull, our ability to estimate correct down-range travel criteria is going to be no more precise than a guess. Our discussion of *Math for Marines* on aircraft and weapons error sensitivities will give you a basic understanding of factors that affect weapon performance. (See paragraph 3.6 for a discussion of Loft Delivery.)

3.3.4.1 FLIR/Laser Utilization. One procedure to determine a corrected firing position is to utilize the laser range finding capability of the FLIR and laser. Once the target is identified, it can then be located on the FLIR. After completion, align the FLIR to the nose of the aircraft and the target downrange of the nose. During our preflight planning we can determine the downrange travel of the weapon (motor/fuze/warhead) and convert the distance from feet to meters. As we continue our run-in to the target, we begin lasing it from a standoff range. As we continue to drive inbound, the reading continues to count down. When the range reading off the laser range finder equals the distance computed for downrange travel, we now have a workable firing solution. Realize that this is not exact science, but will enable us to better estimate and eliminate the biggest variable in level delivery considerations. With practice, workable target marks can be achieved for both day and night operations.

3.4 STRAFING

The characteristics of aircraft guns that make them highly effective against a wide variety of targets are versatility, accuracy, and sustained concentration of fire. The three basic types of strafing that may be required in combat are suppression, line targets, and point targets. Suppression-type strafing is generally used in conjunction with bomb or rocket runs to *keep their heads down.* When strafing a line target, such as a convoy, column of troops, or trench, firing is usually commenced at extremely long slant ranges and a series of bursts, either long or short, is repeated until recovery is initiated. During line target strafing, the pilot can use actual impacts to adjust the aim point. When strafing a point target, the pilot attempts to meet specific firing parameters with a predetermined sight angle. The pipper is held on the target during the firing burst.

The delivery feature that makes strafing effective is that the pilot can assess delivery accuracy and make cor-

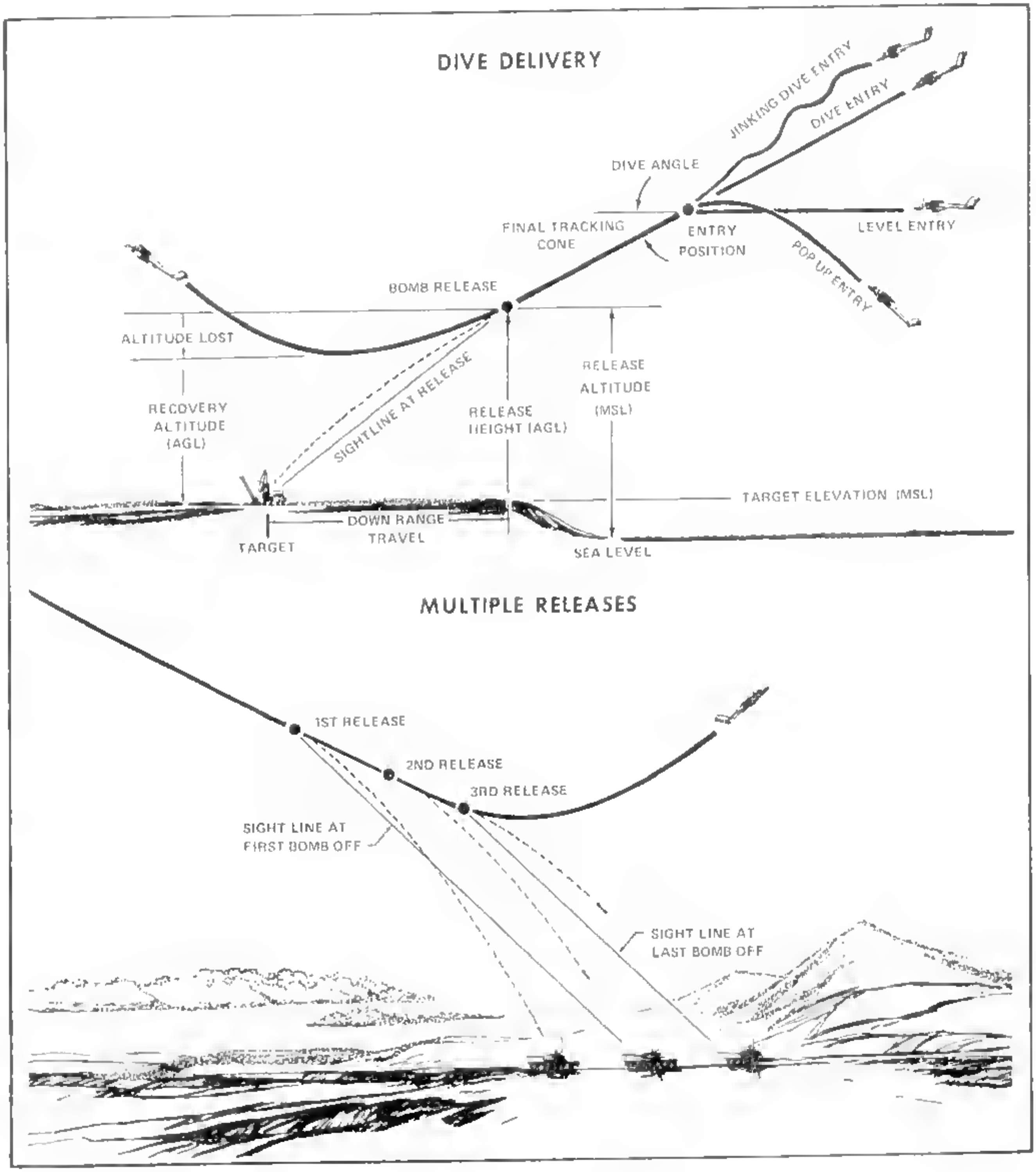


Figure 3-3. Delivery Maneuvers (Sheet 1 of 2)

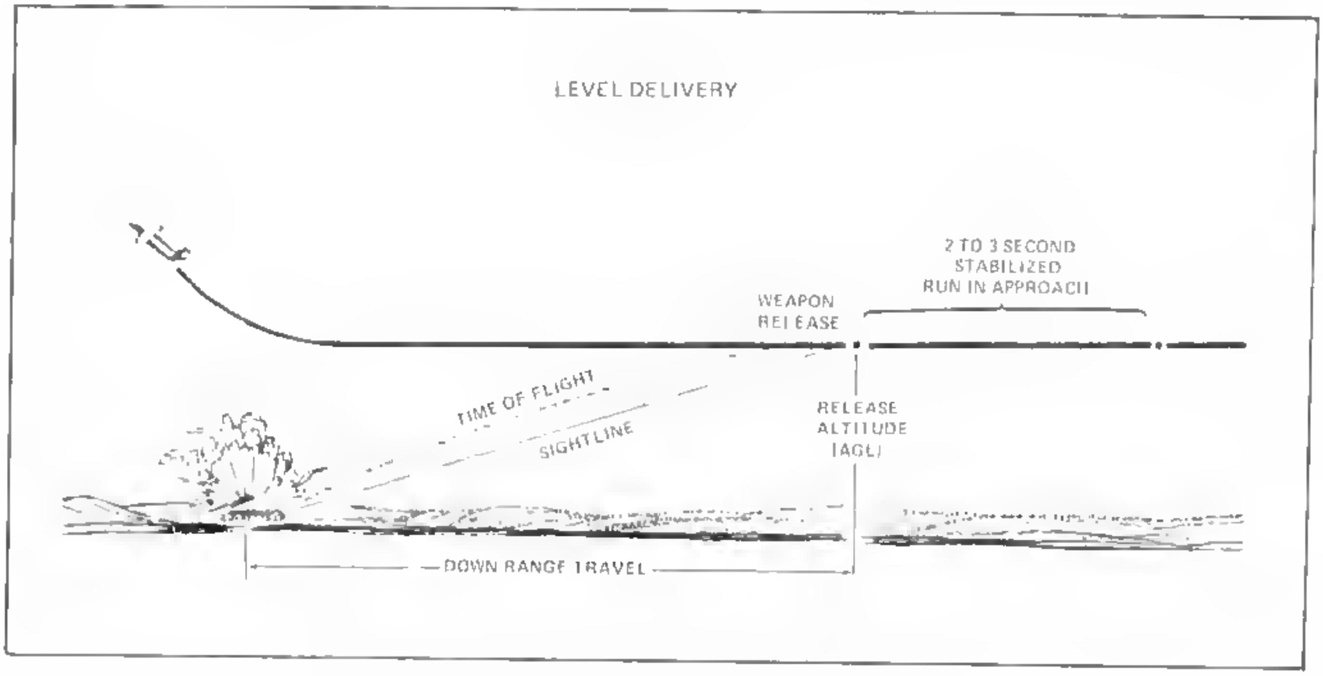


Figure 3-3. Delivery Maneuvers (Sheet 2 of 2)

The delivery feature that makes strafing effective is that the pilot can assess delivery accuracy and make corrections during a long firing burst by observing the flight of tracer projectiles and bullet impact. Effective low-angle strafing range can extend to 4,000 feet when utilizing 20 mm; however, the effective strafing range will increase with corresponding increase in dive angle up to 3,000 feet in a 30° dive. The choice of delivery maneuver will depend on the target, on the enemy defenses, and on weather conditions in the target areas. For example, a steep dive, coupled with high airspeed, should be used in attacking antiaircraft artillery (AAA) positions in order to pinpoint the target; however, a shallow dive, which is more likely to produce waterline hits, is more effective against small boats or junks. Camouflaged targets are more easily seen when a low-angle attack is conducted at medium speed. Recovery should be initiated as high as possible, consistent with the desired accuracy, to minimize the effectiveness of enemy small arms and automatic weapons fire. Against ammunition dumps, the steeper dive maneuvers are recommended, with recovery being completed above 1,500 feet AGL to avoid explosion fragments.

3.4.1 Strafing Entry. The strafing attack is relatively easy to perform and may be initiated from almost any position with a minimum of preplanning. However, for maximum effectiveness, the pilot should strive for consistent dive angles, slant ranges, and airspeeds. This is best accomplished by initiating the attack from an angle off the desired firing heading of at least 45°. The relationship of dive angles, firing altitudes, and cease-firing altitudes for typical strafing maneuvers are described in the following paragraphs. The roll-in technique should be varied to meet existing conditions. Thus, if the roll-in position appears too far out, the turn-in should be almost level until the desired dive angle is intercepted; or if too close in, the nose should be lowered immediately and pulled through to the desired dive angle. Tracking time will be lost if the roll-in is made too gradually. However, it is difficult to make a precise roll-out from a hard turn, and entry airspeed will be difficult to maintain. A 2g to 3g turn will normally allow an easily controlled roll-in entry on the desired attack heading.

3.4.2 Strafe Tracking. A 3- to 5-second time period should be available for tracking after rolling out on the attack heading. Power should be set during roll-in and adjusted early in the tracking phase. Normally, one airspeed check should be made about midway between roll-in and firing. Depending on rate of approach to the desired firing point, a power correction should be made, after which attention should be concentrated on tracking, firing altitude, and firing. As the roll-in is completed, the pipper is initially placed on, or slightly above (5 to 10 mils), the target and the aircraft is trimmed slightly nose heavy for the release airspeed. As the correct dive angle is established, the pipper is allowed to drop 10 to 20 mils (pilot preference) below the target, after which primary attention is given to deflection alignment. As the aircraft approaches the firing altitude, the pipper is allowed to move up to the desired aiming point. The pipper should reach the aiming point just before the aircraft reaches the firing altitude and must be held steady during firing.

3.4.3 Firing. Firing at the proper slant range is very important; therefore, the firing conditions of dive angle and release altitude are critical. If firing is initiated at a greater range than desired, the initial impacts will be short of the target unless an aiming correction has been made. In addition, pattern density is decreased because of increased dispersion, which results in a larger impact area and reduced effectiveness. Firing at ranges below safe minimum slant range increases chances of ricochet damage. The best known method for arriving at the proper firing slant range is to be established on dive angle and to fire at the proper altitude AGL as indicated by the altimeter. The most important factors in accurate point target strafing is to have the pipper on the target when firing is initiated, and to keep it there for the duration of the firing burst. A slight amount of forward trim is desirable when firing longer bursts. This will help concentrate bullet impacts and will tend to prevent *walking-the-bursts.*

3.4.3.1 Commence Firing Altitude. To determine the altitude at which to commence firing, the altitude loss during firing must be calculated. Altitude loss during firing is a function of airspeed, dive angle, and firing burst length. Chapter 4 provides altitude loss information for firing airspeed of 150, 200, and 250 KTAS and dive angles of 10° to 45°. Downrange travel of the aircraft during firing is also a function of airspeed, dive angle, and firing burst time. This information can also be obtained from Chapter 4.

3.4.3.2 Cease Fire Altitude. Cease fire altitudes for 5.0-second bursts are greater than those for 1.5-second bursts because of the lower striking velocities of those projectiles fired at a greater slant range. The lower striking velocities produce greater maximum altitude of the fragment trajectories. Bursts of approximately 1.5 seconds are normally used in the majority of firing runs. This allows greater accuracy, because of the decreased slant range at cease fire altitude, compared to the longer bursts. The 5.0-second burst length will normally be the maximum. With the M-60, a 6.0-second burst will decrease barrel life.

3.4.4 Strafing Recovery. Recovery should be initiated with a pullup as soon as the trigger is released. If a long burst has been fired, bullet impact may be seen before the aircraft nose blanks out the target. The recovery should be made by breaking away from, instead of over, the target, since this reduces the probability of damage from ricochets, fragments, or an exploding target. It also complicates the prediction problem for defensive ground fire. Where effective missile defenses exist, execute a hard turn to low altitude after recovering to level flight. For undefended targets, reposition and reattack as desired.

3.5 POP-UP DELIVERY

The pop-up attack allows rapid, visual target acquisition and good accuracy, while minimizing the time the aircraft is exposed to antiair threat. Since the aircraft is often not observed until it is in its pop, surprise is a key advantage. A high degree of pilot proficiency is required however, since tracking time is shorter, release altitudes lower, and preflight computations (ordnance selection) more critical than with conventional deliveries.

3.5.1 Pop-Up Entry and Tracking. Ingress to the target area can be made at altitudes from 50 to 500 feet, dependent on the threat. At 500 feet, target acquisition is relatively easy and the pull-up point can be judged visually. At lower altitudes, the ingress will probably have to be plotted on a map. Plan a run-in heading and time to pull up from a selected point. From this point, offset the attack heading 20° to 90° from your run-in heading and 1 to 1.5 nm from the target area to allow for minimum exposure and earlier target acquisition in the pullup.

At the pull-up point, add military power and apply 2g's to 4g's to achieve the desired nose-high attitude. Approaching the desired apex (500 to 2,000 feet AGL), roll to a near-inverted attitude, banking as required for the attack heading, and pull down to the selected dive angle. The level delivery may be chosen when firing against hillsides or to maximize standoff distances; however, a shallow dive (5° to 20°) will provide better accuracy. Since tracking time is normally short, accurate mil settings are important. The pilot must know from previous experience the airspeed he will have when rolling wings level and when ready to fire.

3.5.2 Weapon Release and Recovery. Weapon release should be accomplished with the aircraft in a straight-line flightpath. Recovery should be initiated smoothly and quickly. The aircraft will continue to accelerate during the first part of the recovery. As soon as descent has ceased, the appropriate evasive action may be initiated.

WARNING

Tracking time for this maneuver is significantly less than that of normal higher speed deliveries. Do not concentrate on gunsight tracking to the exclusion of altimeter scan.

3.6 LOFT DELIVERY

The loft delivery is normally used when the surface-to-air threat does not permit conventional delivery and other supporting arms are not available. Using the 2.75-inch rocket, standoff distances of about 3 miles from the target can be attained with little or no exposure to enemy fire. The 5-inch rocket permits standoff distances up to 5 miles. The larger errors inherent in this type of delivery can be minimized with practice (Figure 3-1).

The most common application of this technique is for target marking where the attack pilot will be able to acquire the target using rocket impact as a reference. The airborne controller must keep in mind the long times of flight of the rocket, and the dangers to other aircraft inherent in nose-high deliveries.

3.6.1 Loft Entry. Since the target is often not visible over the nose of the aircraft, especially at low altitude and when employing terrain masking, the gunsight is not used for loft deliveries. Instead, the aircrew computes the range from pullup or release to target and plots this distance on a map. If a recognizable landmark is available at this distance, the pilot uses it to begin his pullup on a direct heading toward the target. If no such landmark exists, he must plan a timed run-in to the pull-up point from a readily identifiable point or landmark.

3.6.2 Pullup and Delivery. Pullup is accomplished at 2g's and the power setting necessary to achieve selected release airspeed. The rocket is fired at a 1g wings level when the attitude and altitude selected are reached.

For example, the basic and most reliable loft is a 3-mile 2.75-inch rocket delivery. An altitude of 200 feet above target altitude, 12°, nose up, and 180 knots has produced CEPs of 100 feet. The attitude gyro should be set at 4° nose down on the deck or set 0 ° at 180 knots in straight and level flight.

Delivery flexibility is improved when using a 5-inch Zuni. Three-, four-, and five-mile release-to-target distances are available at various altitudes which permit high terrain clearance and increased survivability. Additional benefits are increased WP smoke residual, that helps offset high wind dispersal, and improved acquisition by close air support (CAS) aircraft. However, aircrews should be aware of the extreme velocity inherent with the 5-inch rocket, and the possibility of large errors in range if the proper aircraft altitude is not set during loft delivery.

At this time, it is important to discuss some error sensitivities when discussing loft rocket profiles. Because of some inherent inaccuracies in the OV-10 delivery system, a further review is warranted. Assuming your navigation is perfect, we have to solve for speed errors. To convert knots into feet per second, we can use the formula: speed (KIAS) X 1.7= feet/second. We can then come up with some rule of thumb speed conversions:

150 X 1.7 = 255
180 X 1.7 = 306
200 X 1.7 = 340

With these numbers, we can see that if our loft delivery is one-second early or late, we will never be closer than 100 meters.

When correcting for azimuth errors we have a few more variables to deal with. First, the radio magnetic indicator (RMI) limitations are about ±1.5°. One degree equals about 17 mils. Seventeen mils equals 17 feet at 1,000 feet. One degree of azimuth error will be 102 feet at one mile. We can now apply these figures to our rocket motor data to have an appreciation for inherent error rates downrange.

Mk 40 motor at 3 miles (1° off) = 306 feet
Mk 66 motor at 4 miles (1° off) = 408 feet
Zuni motor at 5 miles (1° off) = 510 feet

This data can identify that even if we have a perfect loft heading drawn on our chart, we can still have a minimum of almost a 100 meters or more lateral error simply because of RMI inaccuracies. To further compound azimuth errors, look at rocket pods placement on the aircraft. Since rocket pods are not boresighted on the aircraft, it is possible to have up to a 15-mil error in pod alignment. Assuming 15 mils is almost 1° of error, we can apply the same error rates from the above problem and compound them to get a worst case figure. (Hopefully the two error rates would cancel each other out, but that's a little unlikely.) Once again, in all these figures we have assumed a no-wind condition, perfect navigation, proper nose attitude and have rounded off the decimal points.

The bottom line on loft profiles is to still preplan as much as possible. Utilize PPS or PPOC vice immediate briefs. If it is available, plan your loft points to the center of mass of an engagement area or kill box. A good rule of thumb number is:

1 second of flight equals 100 meters, 1° of error equals 100 meters.

The following information was presented in a *Math for Marines* profile. It was not designed for engineers or physics majors, but to give you some preflight plan-

ning information and cockpit data to understand the variables associated with loft deliveries.

3.6.3 Loft Recovery. When the tactical situation requires use of loft deliveries, the recovery will normally consist of an expeditious descent to terrain masking altitudes.

3.7 PARAFLARE DELIVERY

WARNING

> Overhead paraflare delivery may not be tactically feasible in other than a permissive environment.

Illumination of a target with flares is a challenging and demanding mission often performed by the OV-10. Night search and attack patterns using paraflares vary to meet tactical situations. If possible, no more than four aircraft should be used on this type of mission (including one or two OV-10 aircraft and two strike aircraft). Use of more than four aircraft reduces flexibility and safety. Preflight briefing and planning between the flight leader and his wingman are of primary importance. Flare employment should be planned and dropped so that the maximum burning time over the target is obtained.

3.7.1 Flare Delivery Patterns. Racetrack, circle, figure eight, or triangular patterns are recommended for delivery of paraflares (Figures 3-4 thru 3-7). The following general considerations are applicable while dropping flares.

1. Flare release altitude should be based on burnout at 1,000 feet AGL or lower.

2. Flares should not interfere with attacking aircraft.

3. Run-in direction for flare drops should be selected with wind offset considered.

4. Avoid gaps in target illumination while target is under attack.

5. Plan flares to be dropped 12 o'clock from the target on the run-in line.

3.7.1.1 Loft Delivery of Mk 33 Flares. Using the Mk 71 motor, stand-off distances from 2.5 to 5 nm can be attained using the loft delivery technique described in paragraph 3.6. When utilizing loft illumination, plan to have illumination overhead the target 45 seconds prior to the attack aircraft's TOT.

3.7.1.2 Racetrack Pattern. The racetrack pattern is flown on both sides of the target in accordance with the preflight briefing. The flare aircraft should maintain altitude commensurate with flare burn time during the entire run, while the attack aircraft will vary altitude as necessary to deliver type of ordnance being carried.

Note

> The attack aircraft should maintain an altitude of at least 1,000 feet from the flare aircraft.

Timing for the racetrack pattern should be such that, in the respective patterns, the two aircraft are always 180° out of phase with each other. While the flare aircraft is dropping flares, the attack aircraft should be on the downwind leg of the pattern. Brief and frequent radio communications are necessary to maintain proper position. If both aircraft are carrying flares and ordnance, the exchange of roles between flare drop and attack should occur on the downwind leg. Both aircraft should make the altitude change in this position (Figure 3-4).

3.7.1.3 Circle Pattern. The circle gives the pilots the option of dropping flares or delivering ordnance on each run. The pattern is entered with the lead aircraft dropping flares, then executing a climbing turn to the desired roll-in altitude for ordnance delivery. The wingman, who has been trailing and is higher than the lead, executes an ordnance attack after target illumination, and then makes a climbing turn recovery. The lead aircraft should reach the 180° position as the wingman is in his run. From this position, the lead aircraft can choose to continue at altitude for an ordnance attack or to descend for an additional flare drop. Radio communication is essential, and it is the responsibility of the leader to declare whether the next type of delivery is to be flares or ordnance. The designated flare delivery aircraft should commence descent from altitude at the 180° position (Figure 3-5).

3.7.1.4 Figure Eight Pattern. The figure eight is a pattern designed for section practice in multiple attacks on a target. The figure eight is entered with the lead aircraft dropping flares and executing a climbing reversal turn. The wingman (aft and above the lead) follows the flare drop with an ordnance delivery along the leader's track, and then executes a climbing reversal turn, again along the leader's track. The leader, having completed his reversal turn, executes his first ordnance delivery, followed by the wingman with his second. After delivering ordnance, the lead aircraft again re-

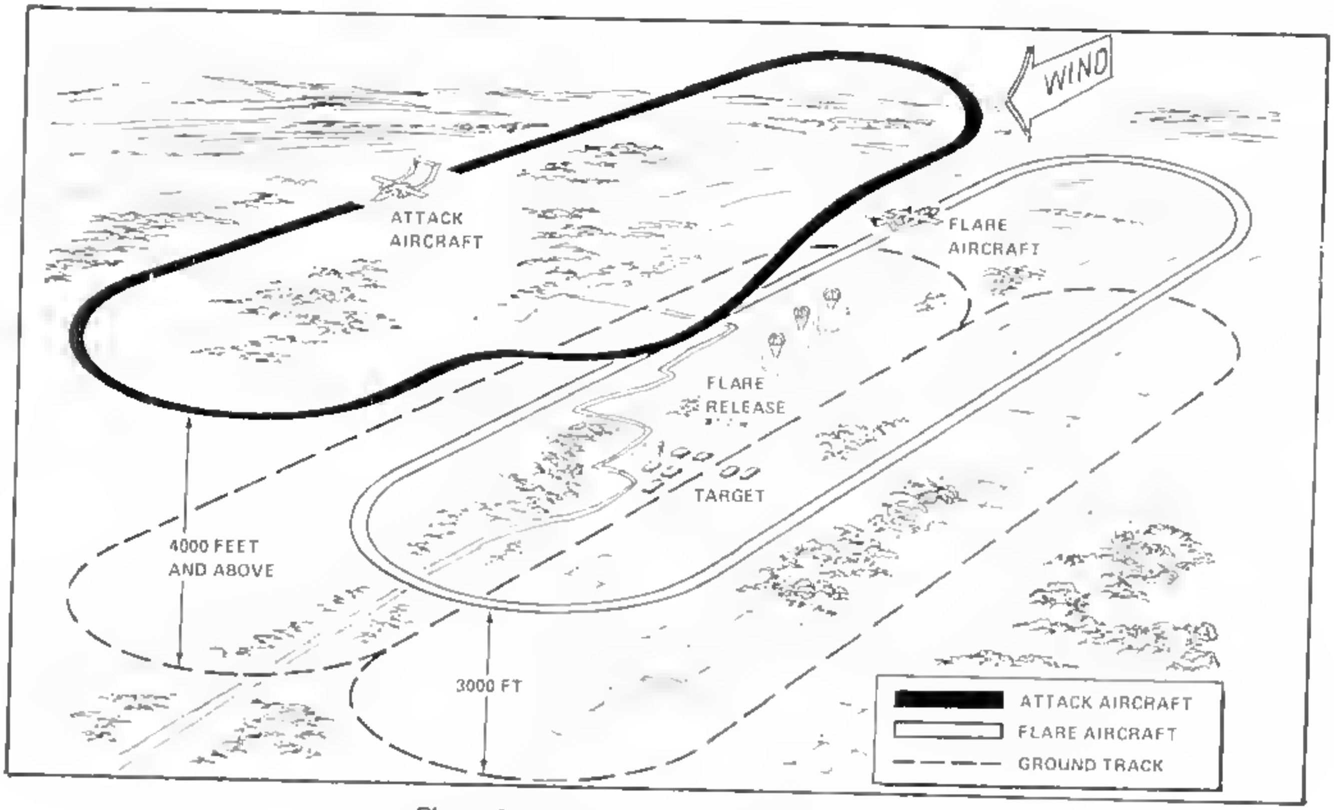


Figure 3-4. Racetrack Delivery Pattern

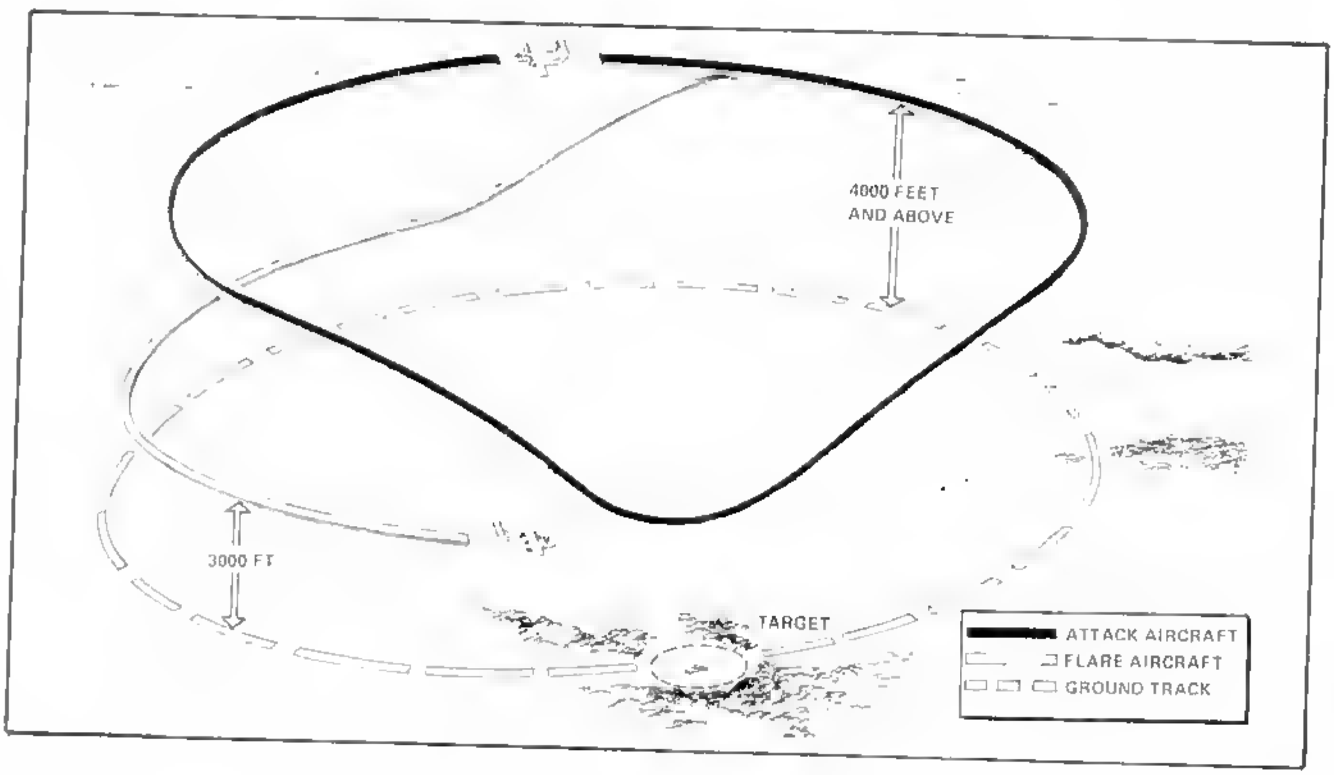


Figure 3-5. Circle Flare Delivery Pattern

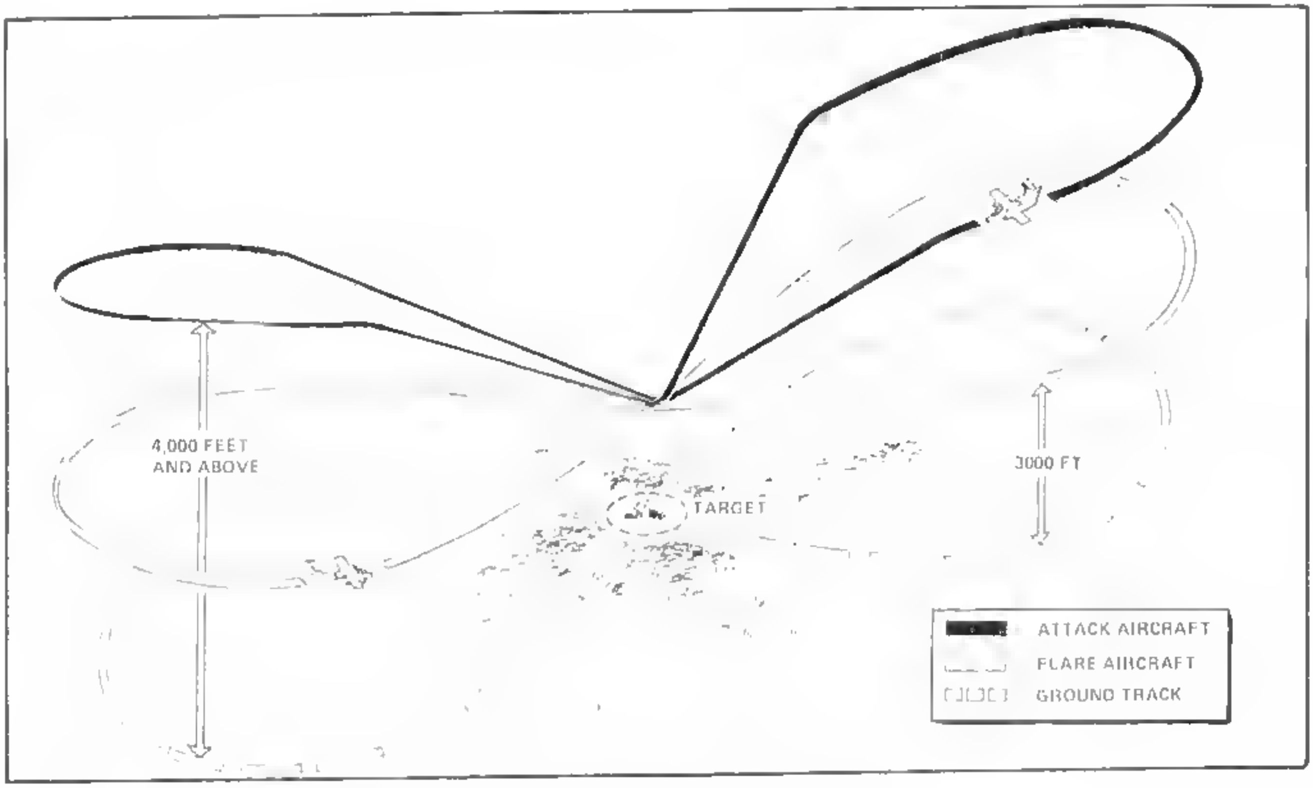


Figure 3-6. Figure Eight Flare Delivery Pattern

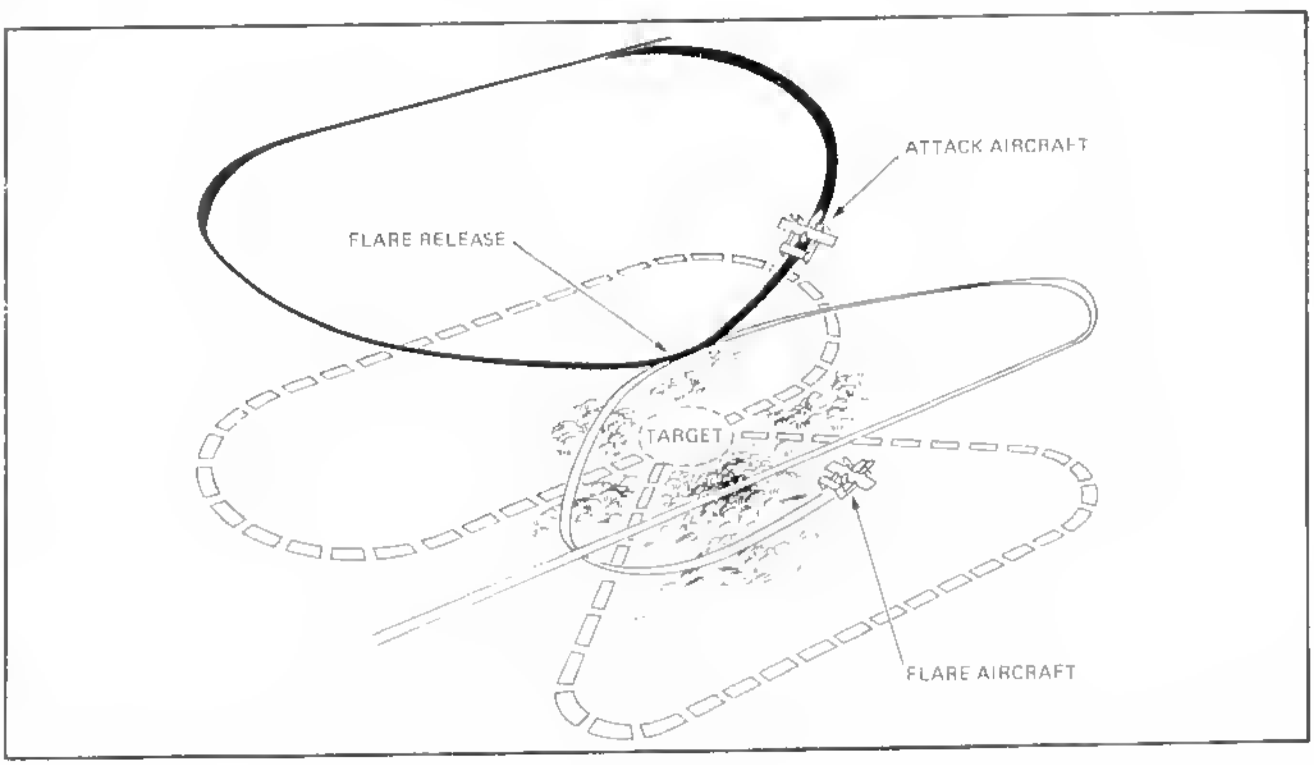


Figure 3-7. Triangular Flare Delivery Pattern

verses at the flare delivery altitude and drops additional flares. Meanwhile, the wingman, having executed another reversal turn, will be in position to make his third ordnance delivery. After this, the leader may decide to commence the sequence again or to break off the attack. Radio communication between aircraft is essential (Figure 3-6).

3.7.1.5 Triangular Flare Pattern. The triangular flare pattern consists of three timed legs and three 120° turns. The pattern is flown so that the inbound and outbound legs are 60° off the attack run-in heading and the middle leg is parallel to the attack heading. This alignment permits the flareship to keep attack aircraft in sight throughout his pattern and, except for brief periods, keeps him clear of the run-in (Figure 3-7).

3.7.1.6 Flare Considerations. The use of a single aircraft for both flare deliveries and FAC(A) may be necessary. Because of the requirements for flares and immediate marking, a well-coordinated crew effort and good outside visual scan are essential. The pilot must maintain his orientation in the pattern, as vertigo and disorientation are a very real danger.

Flares can be used for other purposes than illumination overhead a target. They may be put out at night in the general area of an IP to aid the attack aircraft in their initial run to target. They may also be dropped to ignite just prior to or on the deck to act as a target mark in either the day or night. The threat and the tactical situation, though, will always be the final deciding factor.

CHAPTER 4

Weapon Descriptions

4.1 GENERAL

This chapter contains descriptions and release information for conventional ordnance authorized for carriage and release from the OV-10. The weapons' descriptions consist of illustrations depicting the appearance of the weapon, the physical characteristics, a written description, and a preflight checklist.

Chapter 5 contains descriptions for conventional ordnance of interest to the OV-10 crew, but not authorized for carriage or release from the OV-10.

For ordnance effectiveness against various targets, refer to Joint Munitions Effectiveness Manuals (JMEMs).

4.2 ROCKETS

4.2.1 Introduction. The 2.75-inch and 5.00-inch aircraft rockets, with the selection of warheads available, provide an effective attack capability against a variety of targets. JMEMs provide the applicable data for selecting the rocket/warhead/fuze to best satisfy operational requirements.

An aircraft rocket system consists of a multitude jettisonable launcher loaded with assembled rockets mated to the aircraft station and armament circuitry.

Conventional aircraft rockets have an unguided boost phase and a ballistic flight phase. The motor provides a high impulse over a short period of time and consists of a high strength tube closed at the forward end, a propellant grain, an igniter assembly, and a fin and nozzle assembly. Folding or wrap-around fins allow multiple rockets (4 to 19), dependent on launcher used, to be carried on each authorized station. The launcher tube locking detent prevents forward motion of the rocket until a predetermined force level of the initiated motor is achieved. Departure of the first rocket removes the forward launcher frangible fairing if installed.

4.2.2 Rocket Warheads. The following is a summary of the operational characteristics of warheads used on 2.75- and 5.00-inch rockets. For a more detailed description, refer to NAVAIR 11-85-5.

Rocket warheads are classified according to tactical requirements and functions as follows:

1. HE-FRAG (high-explosive fragmentation)
2. HEAT (high-explosive antitank)
3. AT/APERS (antitank/antipersonnel)
4. GP (high-explosive general purpose)
5. FLECHETTE
6. SMOKE
   (a) WP — white phosphorous
   (b) PWP — plasticized white phosphorous
   (c) RP — red phosphorous
7. FLARE
8. CHAFF
9. PRACTICE (inert).

4.2.3 Rocket Warheads (2.75 inch). The following paragraphs describe the characteristics of warheads used on 2.75-inch rockets. Refer to Figure 4-1 for warhead/fuze combinations.

4.2.3.1 Mk 1 (HE-FRAG). This warhead is used against personnel and soft targets such as parked aircraft, personnel carriers, radar emplacements, trucks, small craft, etc. The warhead contains approximately 1.4 pounds of HBX-1 or Composition B-4 explosive. Construction is of soft steel and total weight is approximately 6.5 pounds.

Authorized Warhead/Fuze Combinations for use with Mk 4 Mods Motors				
TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
HE-FRAG	Mk 1	M427	48.87	19.79
		Mk 176	47.85	19.92
		Mk 178	47.85	19.92
		Mk 352	48.87	19.59
		FMU-90/B	48.87	19.59
	M151	M427	52.69	22.10
		Mk 352	52.69	22.10
		FMU-90/B	52.69	22.10
FLECHETTE	WDU-4A/A	Model 113A	49.36	22.00
HEAT	Mk 5	Mk 181	47.93	20.12
SMOKE	Mk 67 Mod 0 (WP)	M427	52.69	17.82
		Mk 352	52.69	17.62
		FMU-90/B	52.69	17.62
	Mk 67 Mod 1 (RP)	M427	55.83	22.19
		Mk 352	55.83	21.99
	Mk 156 (WP)	M427	53.43	22.27
		Mk 352	53.43	22.07
		FMU-90/B	53.43	22.07
PRACTICE	Mk 1 (inert)	Mk 178 (inert)	47.85	19.17
	Mk 5 (inert)	Mk 181 (inert)	47.94	19.30
	Mk 61		47.84	19.17
	M151 (inert)	M435 (inert)	52.87	22.10
	M230	M435 (inert)	49.76	21.40
	WTU-1/B		52.87	22.10
	WTU-14/B		51.98	22.83

Figure 4-1. Authorized 2.75-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 1 of 4)

Authorized Warhead/Fuze Combinations for use with Mk 40 Mods Motors				
TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
HE-FRAG	Mk 1	M423	48.87	19.79
		M427	48.87	19.79
		Mk 176	47.85	19.92
		Mk 178	47.85	19.92
		Mk 352	48.87	19.59
		FMU-90/B	48.87	19.59
	M151	M423	52.69	22.10
		M427	52.69	22.10
		M429	56.51	22.10
		Mk 352	52.69	22.10
		FMU-90/B	52.69	22.10
	M229	M423	65.37	29.42
		M427	65.37	29.42
		M429	66.64	29.74
		Mk 352	65.37	29.22
		FMU-90/B	65.37	29.22
FLECHETTE	WDU-4A/A	Model 113A	49.36	22.00
HEAT	Mk 5	Mk 181	47.93	20.12
SMOKE	Mk 67 Mod 0 (WP)	M423	52.69	17.82
		M427	52.69	17.82
		Mk 352	52.69	17.62
		FMU-90/B	52.69	17.62
	Mk 67 Mod 1 (RP)	M423	55.83	22.19

Figure 4-1. Authorized 2.75-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 2 of 4)

Authorized Warhead/Fuze Combinations for use with Mk 40 Mods Motors (Continued)				
TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
SMOKE	M156 (WP)	M423	53.43	22.27
		M427	53.43	22.27
		Mk 352	53.43	22.07
		FMU-90/B	53.43	22.07
PRACTICE	Mk 1 (inert)	Mk 178 (inert)	47.85	19.17
	Mk 5 (inert)	Mk 181 (inert)	47.94	19.30
	Mk 61		47.84	19.17
	M151 (inert)	M435 (inert)	52.87	22.10
	M230	M435 (inert)	49.76	21.40
	M229 (inert)	M435 (inert)	65.37	28.80
	WTU-1/B		52.87	22.10
	WTU-14/B		51.98	22.83

Figure 4-1. Authorized 2.75-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 3 of 4)

Authorized Warhead/Fuze Combinations for use with Mk 66 Mod 2 Motors

TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
HE-FRAG	M151	M423	54.39	22.95
		M427	54.39	22.95
		Mk 352	54.39	22.95
FLECHETTE	WDU-4A/A	Model 113A	59.75	22.95
SMOKE	Mk 67 Mod 0 (WP)	M423	55.13	18.75
		M427	55.13	18.75
		Mk 352	55.13	18.75
	Mk 67 Mod 1 (RP)	M427	57.79	22.52
		Mk 352	57.79	22.52
	M156 (WP)	M423	55.13	23.25
		M427	55.13	23.25
		Mk 352	55.13	23.25
PRACTICE	WTU-1/B		55.13	22.95
FLARE	M257	M442	73.25	24.45

Figure 4-1. Authorized 2.75-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 4 of 4)

4.2.3.2 M151 (HE-FRAG). Tactical application of the warhead is the same as the Mk 1. The warhead contains approximately 2.3 pounds of Composition B-4 explosive. Construction is of soft steel or cast iron and total weight is approximately 9.4 pounds.

4.2.3.3 M229 (HE-FRAG). This warhead is an elongated version of the M151 warhead. It has the same tactical application and is designed ONLY for use with slow speed aircraft and the Mk 40 rocket motor. The warhead contains approximately 4.8 pounds of Composition B-4 explosive. Total weight is approximately 16.9 pounds.

4.2.3.4 Mk 5 (HEAT). This warhead is used against armored targets such as tanks, bunkers, armored vehicles, etc. The warhead contains a shaped-charge that produces a high energy jet that penetrates armor. It contains approximately 0.9 pounds of Composition B explosive. Construction is of steel and total weight is approximately 6.6 pounds.

4.2.3.5 WDU-4A/A (FLECHETTE). This warhead is used against personnel and lightly armored targets. It contains 2,200 small arrow-shaped projectiles (flechettes), that are expelled near motor burnout. Target damage is caused by the high impact velocity of the flechettes. The warhead casing is constructed of light metal with a plastic nose section. The Model 113A fuze is permanently installed and initiates the expulsion charge after motor burnout. Total weight is approximately 9.3 pounds.

4.2.3.6 Mk 67 (SMOKE). This warhead is used to provide smoke for target marking and is available in two Mods, 0 and 1. The Mod 0 filler is white phosphorous (WP) that requires special handling. The Mod 1 contains red phosphorous that has improved cookoff characteristics and does not require special handling. The warhead casing is constructed of aluminum alloy. An explosive burster charge of Composition B disperses the 2.6 pounds of white/red phosphorous. Total weight is approximately 5.2 pounds.

4.2.3.7 M156 (SMOKE). This warhead is identical in function to the Mk 67 but uses a soft steel casing. An explosive burster charge of Composition B-4 disperses the 2.0 pounds of white phosphorous (WP). Total weight is approximately 9.7 pounds.

4.2.3.8 M257 (FLARE). The M257 flare warhead is used to provide delivery aircraft with a standoff capability for battlefield illumination. This enables the delivery aircraft to attack the target area using the illumination the flare provides. The permanently installed base fuze (M442) functions near motor burnout and provides for a 9.0-second delay prior to drogue chute deployment and subsequent main chute deployment and flare ignition. Total elapsed time from motor ignition to flare illumination is approximately 13.5 seconds. The warhead produces 1,000,000 candlepower for a minimum of 100 seconds and illuminates approximately one square mile of area. Average descent of the deployed flare is 13 feet/second. The warhead is launched to attain a flare ignition altitude of 1,800 feet at a range of 3,000 meters with the Mk 40 motor and 3,500 meters with the Mk 66 motor. Total weight of the warhead is 10.7 pounds.

4.2.4 Practice Warheads (2.75 Inch). Practice warheads (Figure 4-2) are either dummy configurations or inert-loaded service warheads in which the weight and placement of an inert filler gives the practice warhead and the explosive-loaded service warhead the same ballistic characteristics and MUST BE DELIVERED within the same parameters as service warheads.

Practice	Service
Mk 1, Mk 61, WTU-14/B	Mk 1
Mk 5	Mk 5
M151, M230, WTU-1/B	M151
M229	M229

Figure 4-2. Practice Warheads Used to Simulate Service Warheads

WARNING

In some cases, the same Mk and Mod numbers have been assigned to both service and practice warheads. Personnel should verify that warhead markings are correct and that practice and service warheads are NOT interchanged.

4.2.5 Rocket Warheads (5.00 Inch). The following paragraphs describe the characteristics of warheads used on 5.00-inch rockets. Refer to Figure 4-3 for warhead/fuze combinations.

4.2.5.1 Mk 24 (GP). This high-explosive general purpose warhead can be used against a variety of targets including concrete buildings or bunkers, surface vessels, etc. Tactical use is dependent on fuzing configuration. The Mod 0 has a permanently installed base fuze. Mods 1/2 do not have a base fuze. It contains approximately 9.5 pounds of Composition B explosive. Total weight is approximately 45.0 pounds.

4.2.5.2 Mk 32 (AT/APERS). This warhead is effective against heavy or light armored targets. Against heavily armored targets, a point detonating fuze is used to initiate the shaped charge. For light targets, a proximity fuze is used. It contains approximately 15.0 pounds of Composition B explosive. Total weight is approximately 43.5 pounds.

4.2.5.3 Mk 33 (FLARE). This warhead is designed for illuminating surface areas at a distance ahead of the delivery aircraft so that the launching aircraft may avail itself of the parachute suspended flare in attacking the target. The permanently installed mechanical time fuze (i.e., Mk 93 Mod 0) functions approximately 15 seconds after launch and initiates the expulsion and ignition of the flare from the warhead casing. Flare burn time is approximately 90 seconds. Illumination is 1,000,000 candlepower with a descent rate of 18.5 feet/second. Total weight is approximately 46.0 pounds.

4.2.5.4 Mk 34 (SMOKE). This warhead is designed for target marking or incendiary use when a Mk 93 proximity fuze is installed. This warhead is available in two Mods, 0 and 2. The Mod 0 filler is plasticized white phosphorous (PWP) which requires special handling and provides a smoke screen duration of approximately 4 to 5 minutes. The Mod 2 contains red phosphorous (RP) that has improved cookoff characteristics and does not require special handling. The Mod 2 smoke cloud size is the same as the Mod 0, however, duration is only 2 minutes. Both warheads contain approximately 19.3 pounds of phosphorous with a total weight of approximately 51.0 pounds.

4.2.5.5 Mk 63 (HE-FRAG). This warhead is designed to produce large quantities of fragments in an effective air burst pattern. The warhead is proximity fuzed to take advantage of the designed uniform fragment distribution. Some Mods also contain zirconium cubes or rings to give the warhead an incendiary effect in addition to its fragmentation capability. It contains approximately 15.0 pounds of Composition B explosive. Total weight is approximately 56.5 pounds.

4.2.5.6 Mk 84 Mod 4 (CHAFF)/RR-182/AL CHAFF Countermeasures Head. This warhead provides a standoff method of chaff employment along a selected flight corridor in advance of strike aircraft. The warhead consists of a permanently installed mechanical time fuze (FMU-136/B), a main burster charge, and 12 macrocassettes filled with multifrequency chaff dipoles. The fuze is preflight selectable (3 to 80 seconds) and functions at completion of the required motor acceleration. The macrocassettes are expelled by the main burster charge, and after a short delay, each cassette bursts, expelling the chaff dipoles. Refer to VX-5 Expendables OTG for chaff dispersal cloud data and radar cross section (RCS) effectivity. Total weight is approximately 47.0 pounds.

4.2.6 Practice Warheads (5.00 Inch). Practice warheads (Figure 4-4) are either dummy configurations or inert-loaded service warheads in which the weight and placement of an inert filler give the practice warhead and the explosive-loaded service warhead the same ballistic characteristics and MUST BE DELIVERED within the same parameters as service warheads.

WARNING

In some cases, the same Mk and Mod numbers have been assigned to both service and practice warheads. Personnel should verify that warhead markings are correct and that practice and service warheads are not interchanged.

4.2.7 Rocket Motors. All airborne rocket motors (Figures 4-5 and 4-6) include the following components: an igniter, propellant grain with a stabilizing rod, nozzle, fin assembly, and firing contact disc/band. The motor is ignited by 28-vdc aircraft power distributed by the launcher intervalometer to each tube firing contact. Gas pressure resulting from the burning igniter charge ruptures the igniter case and ignites the propellant grain. Propellant gases rupture the nozzle seal/seals and exert forward pressure (resulting in motor movement) which overcomes the launcher tube locking detent. The salt-coated stabilizing rod, located in the center of the propellant grain, prevents unstable burning of the grain and reduces flash and afterburning which contribute to compressor stalls and flame out of jet engines. The folding fins (FFAR) on the

Authorized Warhead/Fuze Combinations for use with Mk 71 Mod 0 Motors				
TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
HE-FRAG	Mk 63 Mod 0	Mk 93 Mod 0 / M414A1	102.79	125.65
		Mk 352 with BBU-15/B	102.79	125.65
		FMU-90/B with BBU-15/B	102.79	125.65
HE-GP	Mk 24 Mod 0, 1, 2	Mk 93 Mod 0 / M414A1	87.78	112.55
		Mk 188 Mod 0	87.78	112.55
		Mk 191 Mod 0	87.78	112.55
		Mk 352 Mod 2 with BBU-15/B	87.78	112.55
		FMU-90/B with BBU-15/B	87.78	112.55
AT/APERS	Mk 32 Mod 0	Mk 93 Mod 0 / M414A1	99.01	111.48
		Mk 188 Mod 0	99.01	111.48
		Mk 352 Mod 2 with BBU-15/B	99.01	111.48
		FMU-90/B with BBU-15/B	99.01	111.48
SMOKE	Mk 34 Mod 0 (WP)	Mk 93 with special adapter	108.0	114.71
		Mk 188 Mod 0	108.0	114.71
		Mk 352 Mod 2 with BBU-15/B	108.0	114.71
		FMU-90/B with BBU-15/B	108.0	114.71
	Mk 34 Mod 2 (RP)	Mk 93 Mod 0	100.99	121.55
		Mk 188 Mod 0	100.99	121.55
		Mk 352 Mod 2 with BBU-15/B	100.99	121.55

Figure 4-3. Authorized 5.0-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 1 of 4)

Authorized Warhead/Fuze Combinations for use with Mk 71 Mod 0 Motors (Continued)				
TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
CHAFF / COUNTER-MEASURES	Mk 84 Mod 4 / RR-182/AL	FMU-136/B	87.78	112.55
FLARE	Mk 33 Mod 1	Mk 193 Mod 0	101.42	112.75
PRACTICE	Mk 6 Mod 7 Mk 24 Mod 0 Mk 32 Mod 1 WTU-11/B	Nose plug Nose plug/ogive Nose plug Mk 93 Mod 0 (inert)	86.88 86.16 102.589 111.193	115.68 115.23 113.45 126.00

Figure 4-3. Authorized 5.0-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 2 of 4)

Authorized Warhead/Fuze Combinations for use with Mk 71 Mod 1 Motors

TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
HE-FRAG	Mk 63 Mod 0	Mk 93 Mod 0 / M414A1	109.49	138.30
		Mk 352 with BBU-15/B	109.49	138.30
		FMU-90/B with BBU-15/B	109.49	138.30
HE-GP	Mk 24 Mod 0, 1, 2	Mk 93 Mod 0 / M414A1	94.48	125.2
		Mk 188 Mod 0	94.48	125.2
		Mk 191 Mod 0	94.48	125.2
		Mk 352 Mod 2 with BBU-15/B	94.48	125.2
		FMU-90/B with BBU-15/B	94.48	125.2
AT/APERS	Mk 32 Mod 0	Mk 93 Mod 0 / M414A1	105.71	124.13
		Mk 188 Mod 0	105.71	124.13
		Mk 352 Mod 2 with BBU-15/B	105.71	124.13
		FMU-90/B with BBU-15/B	105.71	124.13
SMOKE	Mk 34 Mod 0 (WP)	Mk 93 with special adapter	114.71	121.5
		Mk 188 Mod 0	114.71	121.5
		Mk 352 Mod 2 with BBU-15/B	114.71	121.5
		FMU-90/B with BBU-15/B	114.71	121.5
	Mk 34 Mod 2 (RP)	Mk 93 Mod 0	107.69	134.20
		Mk 188 Mod 0	107.69	134.20
		Mk 352 Mod 2 with BBU-15/B	107.69	134.20

Figure 4-3. Authorized 5.0-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 3 of 4)

Authorized Warhead/Fuze Combinations for use with Mk 71 Mod 1 Motor (Continued)				
TYPE	WARHEAD	FUZE	Overall Rocket Length (inches)	Nominal Rocket Weight (pounds)
CHAFF / COUNTER-MEASURES	Mk 84 Mod 4 / RR-182/AL	FMU-136/B	94.48	125.2
FLARE	Mk 33 Mod 1	Mk 193 Mod 0	108.12	125.40
PRACTICE	Mk 6 Mod 7	Nose plug	93.58	128.33
	Mk 24 Mod 0	Nose plug/ogive	92.86	127.88
	Mk 32 Mod 1	Nose plug	109.289	134.20
	WTU-11/B	Mk 93 Mod 0 (inert)	117.893	138.64

Figure 4-3. Authorized 5.0-Inch Aircraft Rocket Warhead/Fuze Combinations (Sheet 4 of 4)

Practice	Service
Mk 6 Mod 7, Mk 24	Mk 24
Mk 32	Mk 32
WTU-11/B	Mk 63

Figure 4-4. Practice Warheads Used to Simulate Service Warheads

Mk 4/40 2.75-inch motors are forced open by propellant gases as the motor exits the launcher tube. The wrap-around (WAFFAR) fins on the Mk 66 2.75-inch and Mk 71 5.00-inch motors are spring actuated to open and seat in the nozzle body fin slots as the motor exits the launcher tube.

4.2.7.1 Mk 4 Rocket Motor (2.75 Inch). The Mk 4 rocket motor produces an average thrust of 710 pounds and is used with all configurations of the 2.75-inch FFAR for fixed-wing aircraft and SHOULD NOT BE used for extremely low-speed launch velocities. Approximate motor weight is 11.4 pounds.

4.2.7.2 Mk 40 Rocket Motor (2.75 Inch). The Mk 40 rocket motor is identical to the Mk 4 with the exception of the nozzles. They are scarfed to provide rotational spin and stabilization when fired at low initial launch velocities. The Mk 40 was specifically designed for helicopters and slow-speed aircraft. Approximate motor weight is 11.4 pounds.

4.2.7.3 Mk 66 Mod 2 WAFFAR Rocket Motor (2.75 inch). The Mk 66 Mod 2 WAFFAR motor is designed to replace the Mk 4/40 FFAR motors and can be carried and launched from both rotary/fixed-wing aircraft. The motor is considered HERO safe and does not require the use of an RF barrier on the aft end of the rocket launcher. The Mk 66 Mod 2 CAN ONLY BE USED in LAU-61C/A and LAU-68D/A rocket launchers. The three spring-loaded wrap-around fins in conjunction with the fluted exhaust nozzle provide controlled spin and stabilized flight. The motor produces an average thrust of 1,360 pounds for a duration of 1.1 seconds. Approximate motor weight is 13.4 pounds.

4.2.7.4 Mk 71 Mod 0 Rocket Motor (5.00 Inch). The Mk 71 Mod 0 motor produces an average thrust of 7,780 pounds for approximately 1.17 seconds. These motors have the same propellant grain and motor tubes as the obsolete Mk 16 motor. The Mk 71 Mod 0 motor has spring-loaded folding wrap-around fins that provide controlled spin and improve the ballistic dispersion of the rocket. Approximate motor weight is 66.85 pounds.

4.2.7.5 Mk 71 Mod 1 Rocket Motor (5.00 Inch). The Mk 71 Mod 1 differs from the Mod 0 by having a different propellant grain and is 6 inches longer. It produces an average thrust of 8,100 pounds for approximately 1.8 seconds. The fin and nozzle assembly incorporates spring-loaded wrap-around fins that provide controlled spin and improve the ballistic dispersion of the rocket. Approximate motor weight is 79.5 pounds.

4.2.8 Rocket Launchers. The rocket launchers currently in service are described in the following paragraphs.

4.2.8.1 LAU-61 Series Rocket Launchers. The LAU-61 (Figure 4-7) is an all-metal reusable launcher with a capacity of 19 2.75-inch rockets. The LAU-61A/A, -61B/A can be loaded with Mk 4/40 rocket motors and the LAU-61C/A with Mk 4/40/66 motors. The launcher has a preflight selectable fire-mode selector switch (RIPPLE/SINGLE) located on the aft bulkhead. When ripple is selected, one aircraft firing pulse fires all rockets with a 40-millisecond interval between departing rockets. The SINGLE position allows only one rocket to be fired for each aircraft firing pulse. The 21-position rotary stepper-switch intervalometer, located on the aft bulkhead, is an electromechanical unit that distributes a firing pulse to each launcher tube motor contact. Each launcher tube has a motor detent retainer that retains the rocket motor until ignition. A frangible nose fairing can be installed to reduce aerodynamic drag and will depart the launcher when the first rocket is fired. The aft fairing is aluminum and is designed to remain intact and direct debris away from the aircraft. The LAU-61B/A and LAU-61C/A have a thermal protective coating on the exterior surface and REQUIRE the use of thermal barriers for all shipboard operations. The aft thermal barrier also provides RF protection for the Mk 4/40 rocket motor. Ground safety is provided by a safe-arm device (switch with safety pin) that opens the circuit from the launcher receptacle and grounds the intervalometer.

WARNING

MIXING of rocket motors is PROHIBITED.

4.2.8.2 LAU-68 Series Rocket Launcher. The LAU-68 (Figure 4-8) is an all-metal reusable launcher with a capacity for seven 2.75-inch rockets. The LAU-68B/A can be loaded with Mk 4/40 rocket motors and

Characteristics

Warhead (Mk 4/40 MTR)	**MK 1/5**	**M151/ WDU-4A/A**	**M229**	**MK 67**	**M156**	**M257**
Weight (Pounds)	18.0	20.8	28.3	16.6	21.0	22.2
Warhead (Mk 66 MTR)		**M151**		**MK 67**	**M156**	**M257**
Weight (Pounds)		22.8		18.6	23.1	24.2

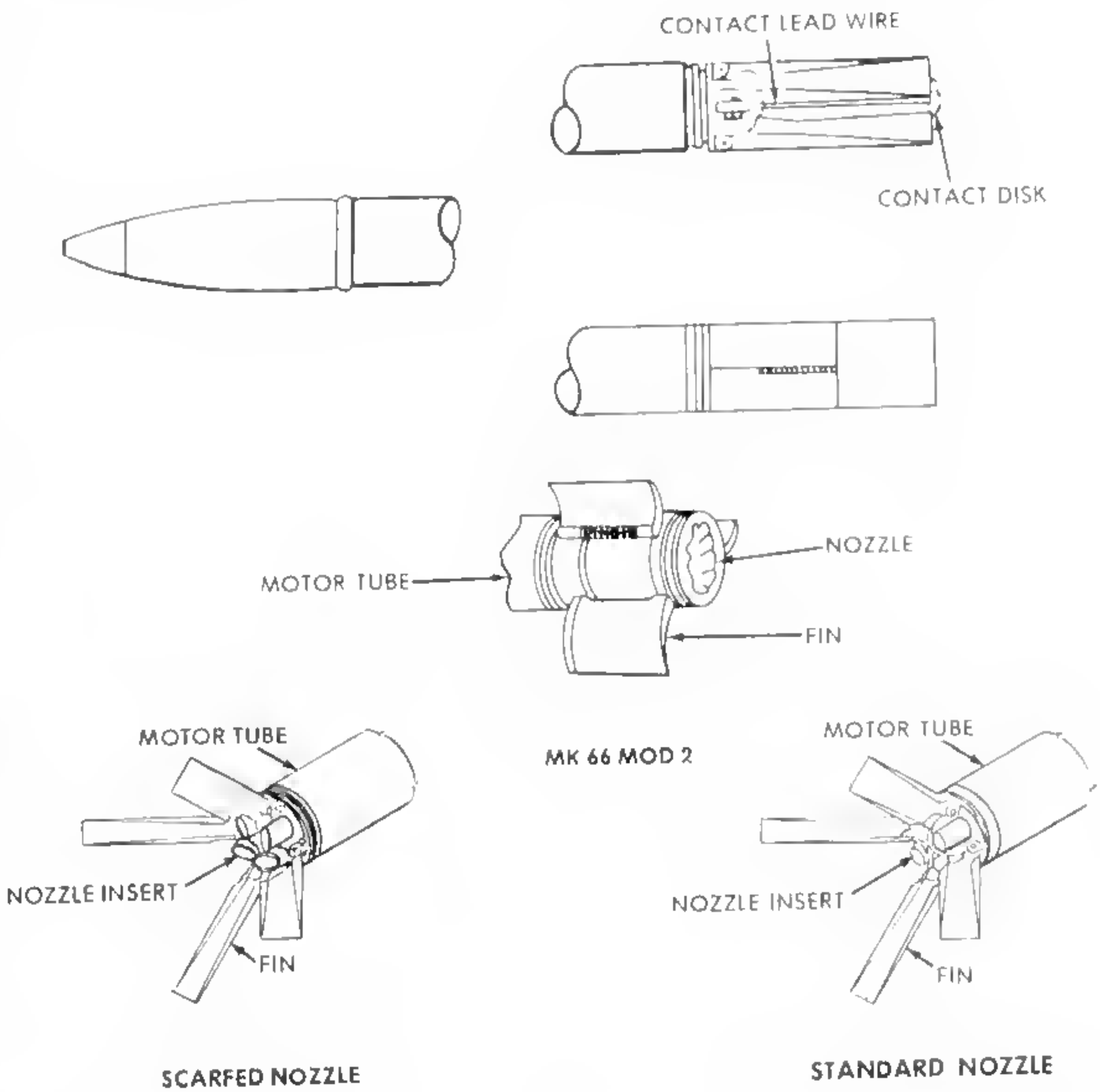


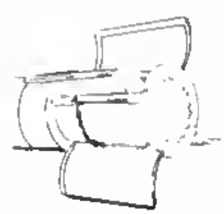
Figure 4-5. 2.75-Inch FFAR Rocket Motor Mk 4/40/66

Characteristics

Warhead	MK 24	MK 32	MK 33	MK 34	MK 63	MK 84 MOD 4 (RR-182A/L)
MK 71 Mod 0 Weight (Pounds)	111.9	110.3	112.8	117.8	123.4	114.0
MK 71 Mod 1 Weight (Pounds)	124.5	122.9	125.4	130.4	136.0	126.6

MK 71 MOD 0 MOTOR

MK 71 MOD 1 MOTOR



MK 71 MOD 0 & 1

Figure 4-6. 5.00-Inch Zuni Motors Mk 71 Mods 0/01

Characteristics

Weight (Pounds)	
(Empty)	128.0 (A/A) - 145 (B/A) - 148 (C/A)
(Loaded w/fairings).	458.4 - 748.56
Length (Inches).	83.0
Diameter (Inches)	15.7
Suspension (Inches)	14.0

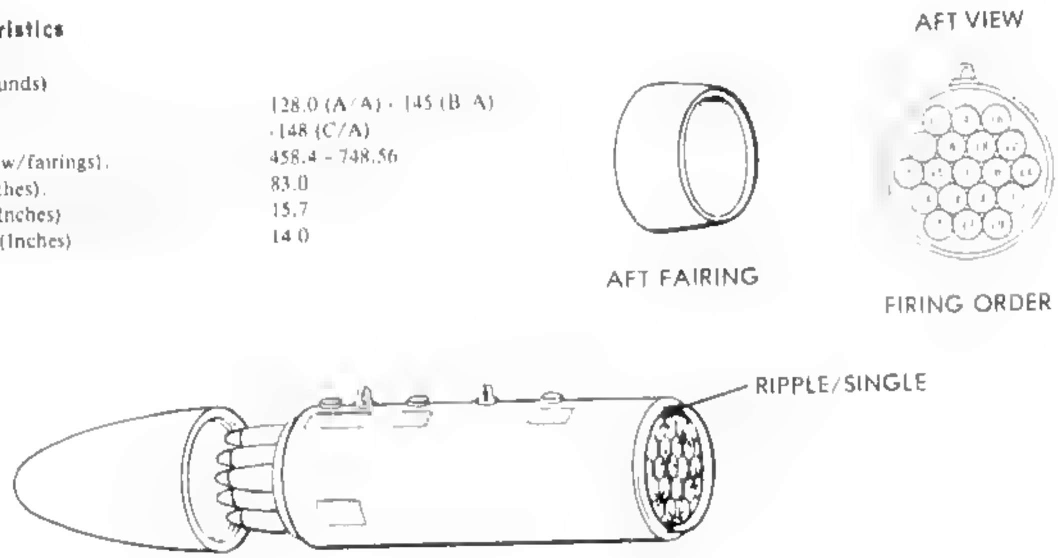


Figure 4-7. Rocket Launchers (2.75-Inch FFAR LAU-61 Series)

LAU-68D/A with Mk 4/40/66 motors. The launcher has a preflight selectable fire-mode selector switch (RIPPLE/SINGLE) located on the aft bulkhead. When RIPPLE is selected, one aircraft firing pulse fires all rockets with a 60-millisecond interval (LAU-68B/A) or 40-millisecond interval (LAU-68D/A) between departing rockets. The SINGLE position allows only one rocket to be fired for each aircraft firing pulse. The nine-position rotary stepper-switch intervalometer, located on the aft bulkhead, is an electromechanical unit that distributes a firing pulse to each launcher tube motor contact. Each launcher tube has a motor detent retainer that retains the rocket motor until ignition. A frangible nose fairing can be installed to reduce aerodynamic drag and will depart the launcher when the first rocket is fired. The aft fairing is aluminum and is designed to remain intact and direct debris away from the aircraft. The LAU-68D/A has thermal protective coating on the exterior surface and REQUIRES the use of thermal barriers for all shipboard operations. The aft thermal barrier also provides RF protection for the Mk 4/40 rocket motor. Ground safety is provided by safe-arm device (switch with safety pin) that opens the circuit from the launcher receptacle and grounds the intervalometer.

WARNING

MIXING of rocket motors is PROHIBITED.

4.2.8.3 LAU-10 Series Rocket Launcher. The LAU-10 (Figure 4-9) is an all-metal reusable rocket launcher with a capacity for four 5.00-inch rockets. The launcher has a preflight selectable fire-mode selector switch (RIPPLE/SINGLE) located on the aft bulkhead. When RIPPLE is selected, one aircraft firing pulse fires all rockets with a 95-millisecond interval between departing rockets. The firing pulse must exceed a 0.5-second duration to ensure a complete fire out when

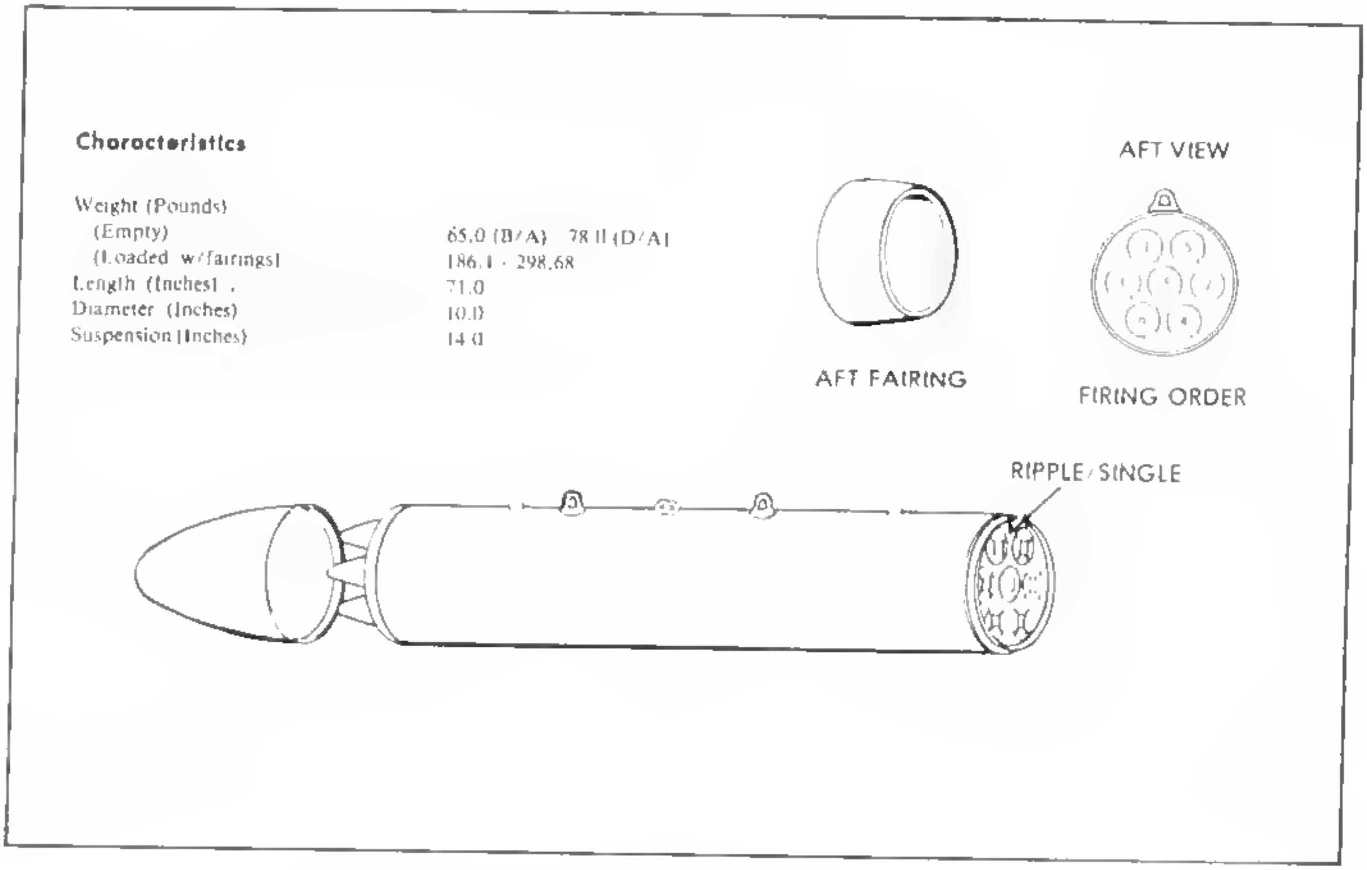


Figure 4-8. Rocket Launchers (2.75-Inch FFAR LAU-68 Series)

RIPPLE is selected. The SINGLE position allows only one rocket to be fired for each aircraft firing pulse. The internal non-selectable rotary stepper-switch intervalometer is an electromechanical unit that distributes a firing pulse to each launcher tube motor contact. Each launcher tube has a motor detent that retains the rocket motor until ignition. Frangible fairings can be installed to reduce aerodynamic drag and will depart the launcher when the first rocket is fired. Thermal coated fairings are required for all shipboard operations. The LAU-10D/A has a thermal protective coating on the exterior surface and REQUIRES the installation of a thermal shield over the aft end of the launcher for all shipboard operations. The thermal shield and fairing provide increased cookoff time in the event of a fire. Ground safety is provided by a safe-arm device (switch with safety pin) that opens the circuit from the launcher receptacle and grounds the intervalometer.

4.2.9 Limitations. Refer to Appendix A, External Stores Limitations Table for carriage and firing/jettison restrictions.

4.2.10 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

4.2.11 Firing Procedures

1. Sight reticle brightness knob — AS REQUIRED
2. FIL SEL switch — NO. 1 or NO. 2
3. Sight depression — AS REQUIRED
4. Appropriate WPN/STATION MODE SELECT switch — FIRE
5. MASTER ARM switch — ON
6. To fire — DEPRESS BOMB BUTTON
7. To drop empty pods — STATION MODE SELECT switches to DROP, and DEPRESS BOMB BUTTON

Characteristics

Weight (Pounds)	
(Empty)	107.0 (C/A) - 136.0 (D/A)
(Loaded w/fairings)	554.9 - 696.4
Length (Inches)	128.9
Diameter (Inches)	13.9
Suspension (Inches)	14.0 and 30.0

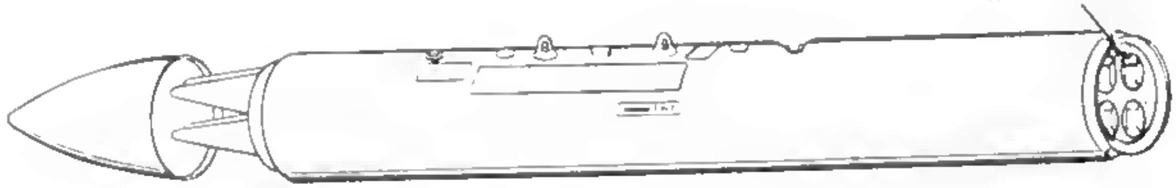


Figure 4-9. Rocket Launcher (5.00-Inch LAU-10 Series)

8. To secure, MASTER ARM switch — OFF

9. WPN/STATION MODE SELECT switch — OFF.

4.3 GUNS

4.3.1 Sponson Guns. The OV-10 has two pairs of M60C 7.62-mm NATO machineguns integrally mounted in each sponson located at the bottom of the fuselage, approximately 0.3 feet behind the observer's cockpit (Figure 4-10).

The M60C guns are electromechanically charged, gas-operated weapons that are adapted from the M60 infantry machinegun. Each pair of guns (left and right) may be charged separately on the ground or inflight. Ground use of the sponson-mounted charging switches requires application of external dc power or that the BATTERY switch be placed ON to energize the primary dc bus. A large diameter gun charger safety pin may be inserted into the upper surface of each sponson for ground safety of the guns.

Note

Although the M60C barrels are cooled by the air stream, maximum burst lengths of 125 rounds (approximately 6 seconds) are recommended to prolong barrel life.

Tracer, ball, and armor-piercing ammunition is available for use with the M60C gun (Figure 4-11).

Associated with the gun pair in each sponson is the feed chute and ammunition can for each gun. Each ammunition can will hold 500 rounds of 7.62-mm belted M60C ammunition, for a total load capacity for both gun pairs of 2,000 rounds. The ammunition is fed through a flexible aluminum feed chute until it reaches the chamber of the gun. The ammunition is continually fed into the gun by the gas-operated recoil mechanism. Link jams (that occur when one of the links belting the ammunition together catches on the feed chute) are common during firing of the last 25 to 30 rounds, since the ammunition belt tends to whip as it comes through the feed chute.

4.3.1.1 M60C Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

4.3.1.2 Firing Procedures (Sponson Guns)

1. Sight reticle brightness knob — AS REQUIRED

2. FIL SEL switch — NO. 1 or NO. 2

3. Sight depression — AS REQUIRED

4. GUNS LH/RH switches — RDY

5. MASTER ARM switch — ON

6. To fire — DEPRESS TRIGGER ON PILOT'S STICK GRIP

7. To secure, GUNS LH/RH switches — CLEAR

8. To secure, MASTER ARM switch — OFF, after a minimum delay of 5 seconds.

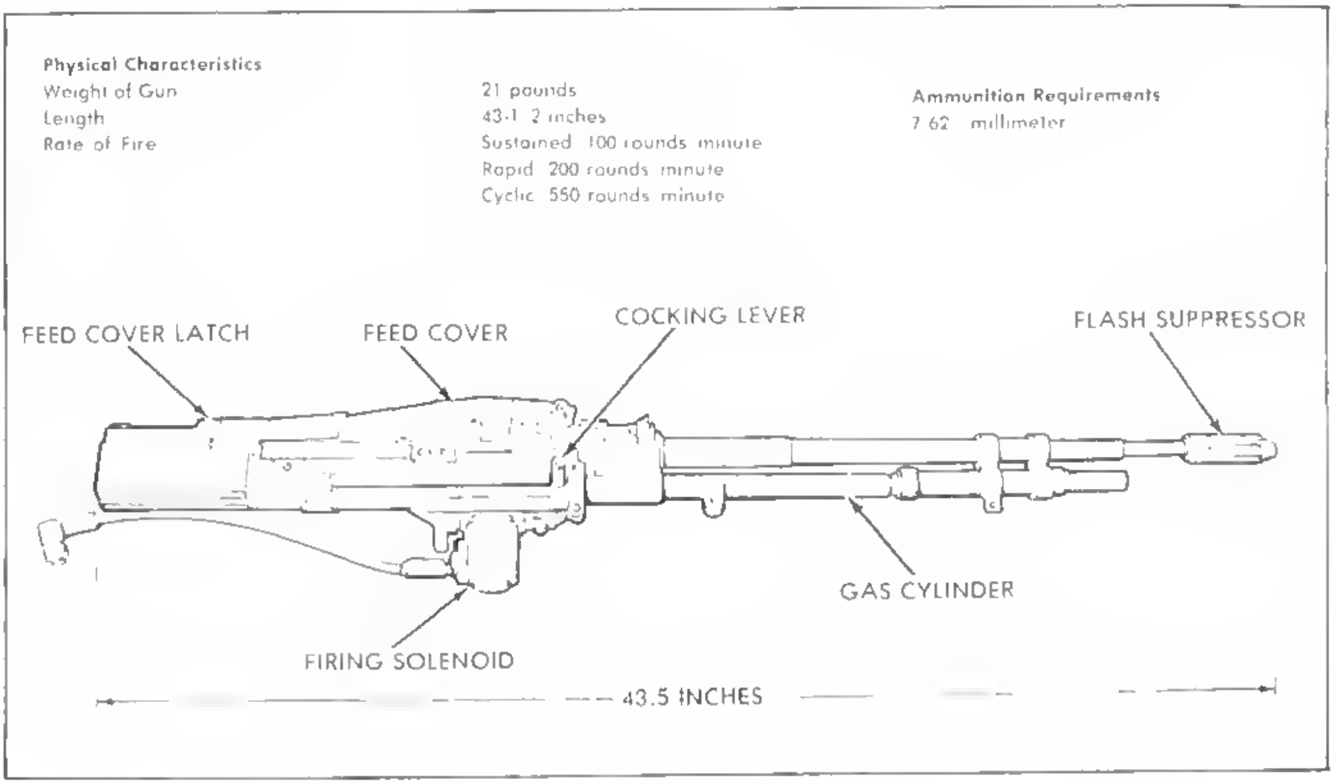


Figure 4-10. Sponson Guns (M60C)

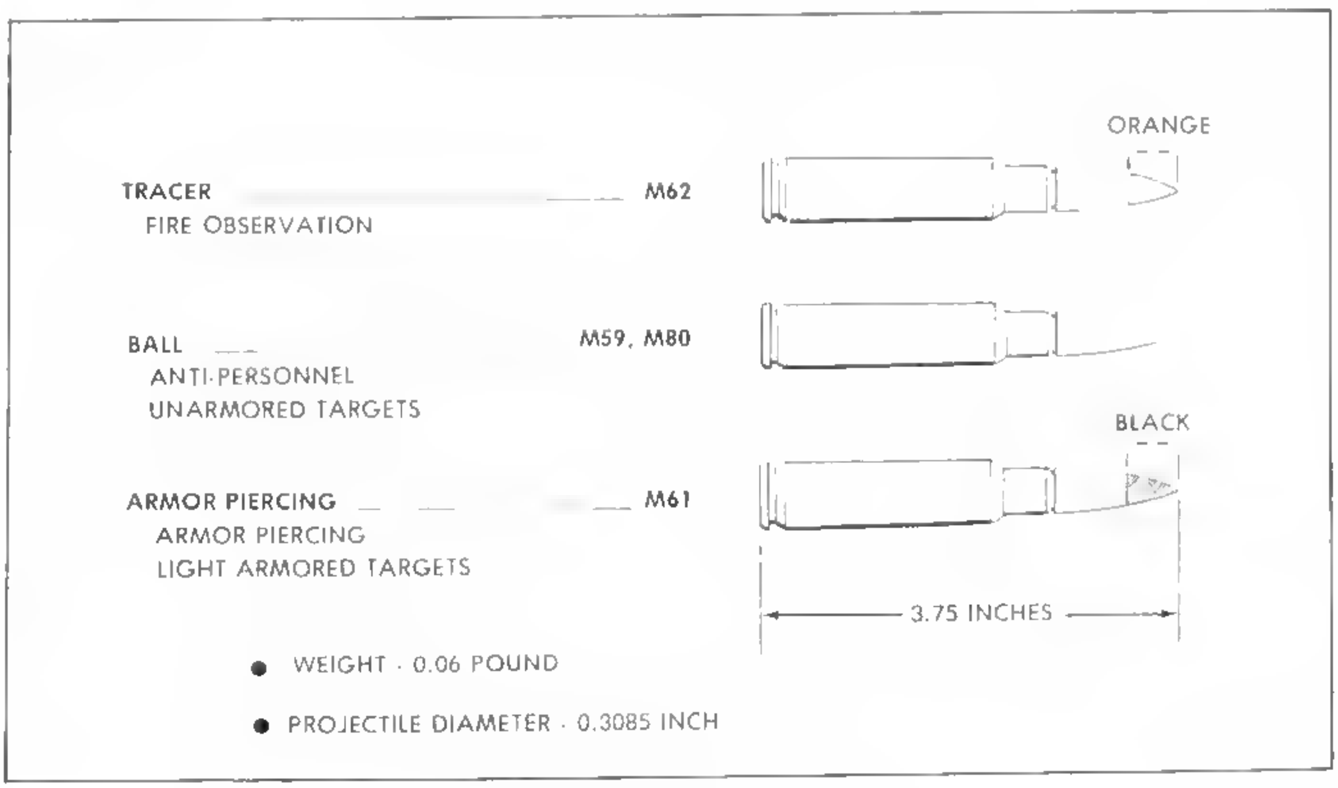


Figure 4-11. 7.62-mm Ammunition

4.4 GPU-2/A GUN POD

4.4.1 Description. The GPU-2/A gun pod (Figure 4-12) is a self-contained gun system consisting of an M197, 3-barrel, 20-mm gun coupled to a single-ended linkless ammunition system, and an ammunition storage drum with a capacity for 300 rounds. The gun pod is equipped with an electrical control system and power supply consisting of a nickel-cadmium battery and charger that drives and sequences the gun system.

The gun pod is designed to mount on suspension racks having 14- or 30-inch hook spacing. The forward suspension lug provides adjustment for boresighting the pod on the aircraft, in both azimuth and elevation within ±2° cone. Any additional boresighting in elevation can be obtained by threading the lugs in or out as needed prior to loading the gun pod.

The gun is electrically operated and fired by the internal battery located in the aft section of the pod with the associated charger that automatically recharges the battery in flight whenever the MASTER ARM switch is selected. The battery has a heater circuit and sensor that functions to maintain the battery at the optimum operating temperature.

The M197 gun provides a 750 or 1,500 rounds per minute (rpm) rate of fire (low/high) that is controlled remotely by the BOMB/FLARE switch in the cockpit. Spent cases are ejected from the gun and out the bottom of the pod. Release of the bomb release button automatically clears the gun.

Ground safety is provided by the fire volts access door located on the right side of the gun support section of the pod. The firing circuitry between the battery and gun is interrupted when the door is in the OPEN position.

4.4.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

4.4.3 Firing Procedures

1. MASTER ARM — ON.

Note

The GPU-2/A is battery operated. Turning the MASTER ARM switch ON provides a trickle charge to this battery.

2. Reticle brightness — AS DESIRED.

Characteristics	
Length (Inches)	127.6
Diameter (Inches)	19.0
Weight (Pounds)	
Empty . .	417.0
Loaded . .	586.0
Suspension (Inches).	14.0/30.0
Capacity (Rounds). .	300 - M50 series
Rate of Fire (RPM). .	750/1500
Maximum Effective Range (Feet)	2000 ft

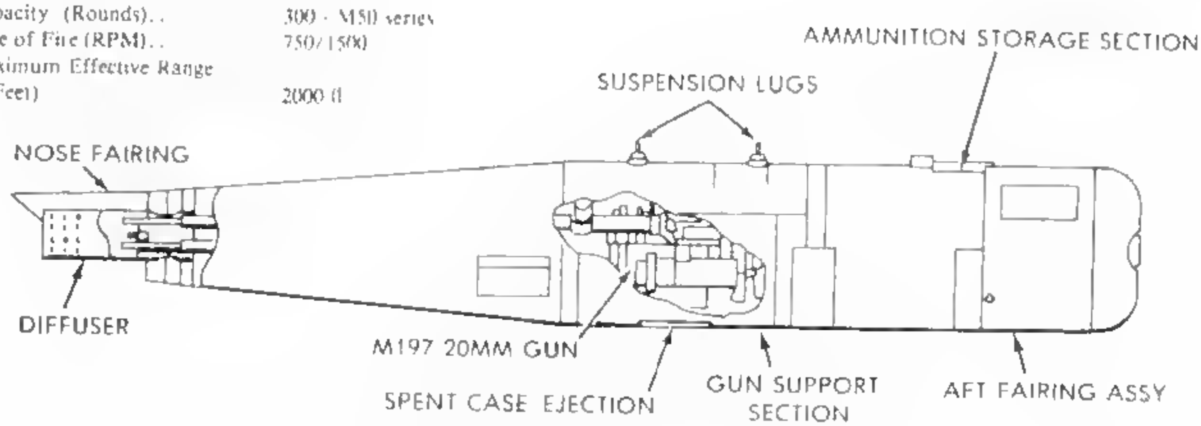


Figure 4-12. GPU-2/A Gun Pod

3. FIL SEL — NO. 1 or NO. 2.

4. Depression — AS DESIRED.

5. STATION MODE SELECT — FIRE.

6. BOMB-FLARE switch

For low rate of fire — SAFE
For high rate of fire* — TAIL.

7. To fire, depress bomb release button.

Note

The pod will continue to fire up to 0.1 second after the bomb button is released as it completes the automatic self-clearing phase. Self-clearing will be initiated if the bomb button is momentarily released during a strafing pass; up to 0.4-second delay may be required to refeed and recommence fire.

4.4.4 Remote Clearing Procedures

CAUTION

Ensure aircraft is in an uninhabitable area when clearing procedures are performed.

Note

This procedure is required only when a jam is suspected since the gun clears itself automatically in normal operation.

1. MASTER ARM — ON

2. STATION MODE SELECT — FIRE

3. BOMB-FLARE switch — NOSE & TAIL.

4.4.5 20-mm Ammunition. A 20-mm round consists of a steel cartridge case, an electric primer, propellant powder, and the projectile. The primer is ignited by 28-volt dc electrical powder from the aircraft armament system. The primer ignites the propellant powder which forms a gas as it burns, forcing the projectile through the gun barrel. There are two classifications of ammunition (M50 series/PGU), the only significant difference is the projectile.

*Authorized only when AAC 716 has been incorporated.

The M50 series ammunition was designed for high altitude air-to-air combat. The ammunition is deficient in the air-to-ground mission because of poor ballistic performance at low altitudes, the inability to penetrate lightly armored ground targets, and a high dud rate.

The projectile gun unit (PGU) series is a multipurpose ammunition developed to be more effective in the air-to-ground mission. The 20-mm PGU semi-armor piercing high explosive incendiary (SAPHEI) projectile is more effective than the M50-series ammunition projectile. The SAPHEI projectile is a combination of hardened steel body and pyrotechnic fuze that allows the projectile to penetrate and detonate inside the target. The detonation ignites the zirconium pellet providing a long, persistent spark for improved fire starting capability. The streamlined projectile reduces the projectile drag coefficient and allows better pyrotechnic ignition resulting in improved graze sensitivity and fewer duds. All PGU projectiles are ballistically the same.

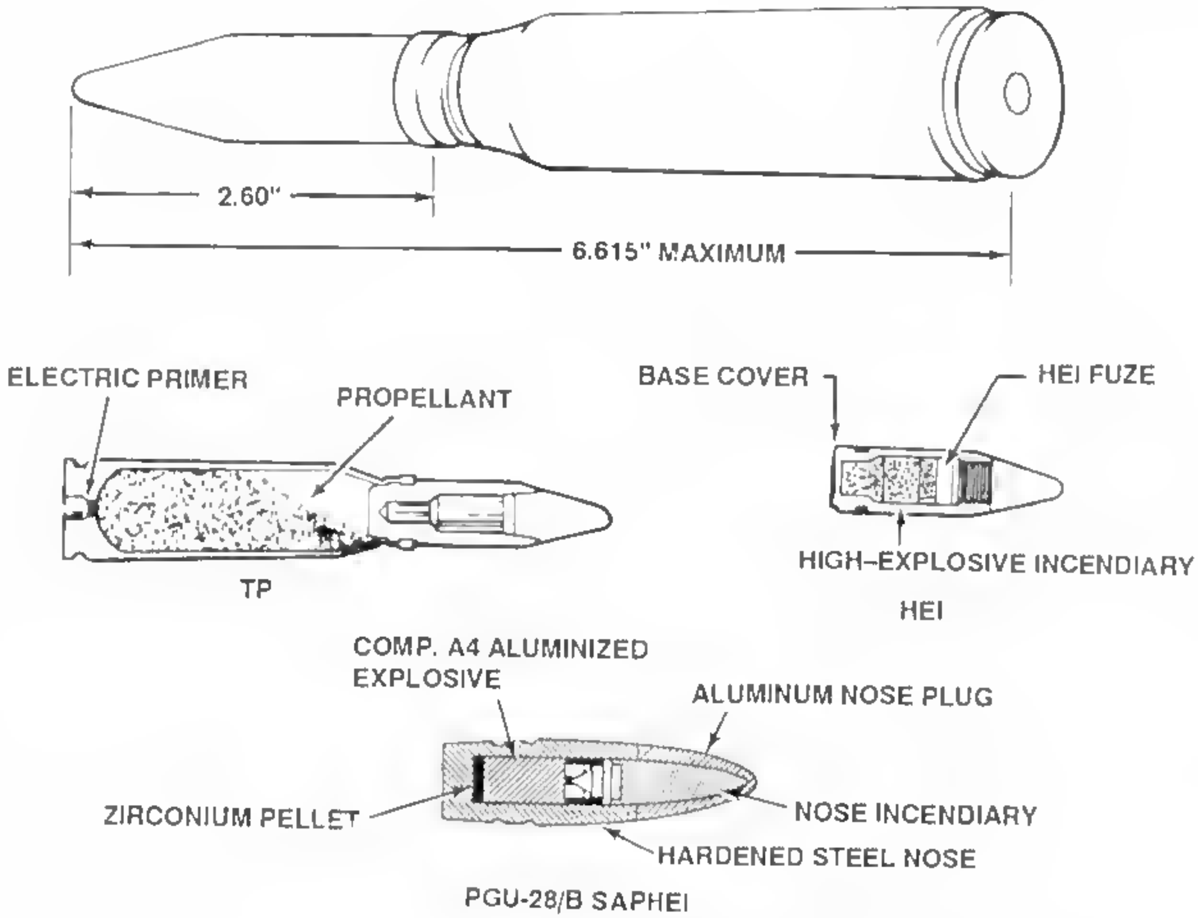
Three types of ammunition are discussed, their significant difference is the projectile (Figure 4-13).

The 20-mm, high-explosive incendiary (HEI) projectile is composed of an incendiary compound, explosive compound, and a fuze. This type of projectile is used against aircraft and light material targets. The PGU-28 SAPHEI projectile replaces the M56 HEI projectile and expands its use to air and ground targets, including light armor.

The 20-mm ball projectile (TP) is a hollow steel body that does not contain a filler. This projectile is used for target practice. The PGU-27 TP projectile replaces the M55 projectile as the target practice projectile.

The M221 target practice-tracer (TP-T) projectile is a steel body with forward and aft cavities. The forward cavity is empty and the aft cavity contains a tracer compound. The PGU-30 TP-T projectile replaces the M221 projectile. The tracer material is a magnesium-teflon-vitron mixture that has exceptionally good visibility in the daylight.

The 20-mm Mk 149 Mod 0 armor piercing discarding SABOT (APDS) ammunition is composed of a Mk 68 Mod 0 projectile that consists of a depleted uranium subcaliber penetrator, an aluminum pusher plug, and a glass-filled, nylon-discarding SABOT that breaks into four segments upon leaving the muzzle. The primary use of this ammunition is against hard material targets such as light armored vehicles. The round is currently undergoing operational testing.



ROUND	APPROXIMATE MUZZLE VELOCITY IN M61A1 (ft/sec)	AVERAGE WEIGHT (LB) COMPLETE ROUND
M56 High Explosive — Incendiary	3,320 (±50)	0.56
M242 High Explosive — Incendiary Tracer	3,380 (±50)	0.56
M55 Target Practice	3,380 (±50)	0.56
M220 Target Practice — Tracer		
PGU-28/B Semi-armor – piercing High Explosive Incendiary	3410	0.79
PGU-27/B Target Practice	3410	0.78
PGU-30/B Target Practice — Tracer	3410	0.78

Figure 4-13. 20-mm Ammunition

4.5 MK 45 MOD 0 AIRCRAFT PARACHUTE FLARE

4.5.1 Description. The Mk 45 Mod 0 aircraft parachute flare (APF) (Figure 4-14) is used for night-time illumination of surface areas in search and attack operations. It is compatible with the SUU-44/A flare dispenser.

The Mk 45 Mod 0 APF provides 210 seconds of 2,000,000 candlepower illumination. The flare components include a fuze, ejection mechanism, parachute suspension system, igniter assembly, pyrotechnic candle, and an aluminum case. The fuze that controls the free-fall distance to parachute deployment and candle ejection has 15 ejection settings between 500 and 14,000 feet of fall and a SAFE setting. The desired functioning delay is selected by positioning the ejection dial to the appropriate setting. Rate of descent is 7 feet/second.

A steel lanyard extracts the safety clip from the ejection dial and pulls the internal disconnect from the fuze mechanism as the flare is dispensed/released which initiates the delay mechanism. At the end of the preset delay, the fuze ignites the expellant which ejects the candle and parachute from the case. The shock of the deployed parachute ignites the candle by means of an igniter assembly. At candle burnout, an explosive bolt severs 10 of the 18 parachute shroud lines causing the parachute to collapse and the flare remains to free fall to the ground thus clearing the airspace of any flare debris hazard.

CAUTION

Flares released from SUU-44/A dispensers require straight and level delivery. Refer to Appendix A, External Stores Limitations Table, for additional restrictions.

4.5.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches). . .	36.0
Diameter (Inches). .	4.9
Weight (Pounds). .	28.0

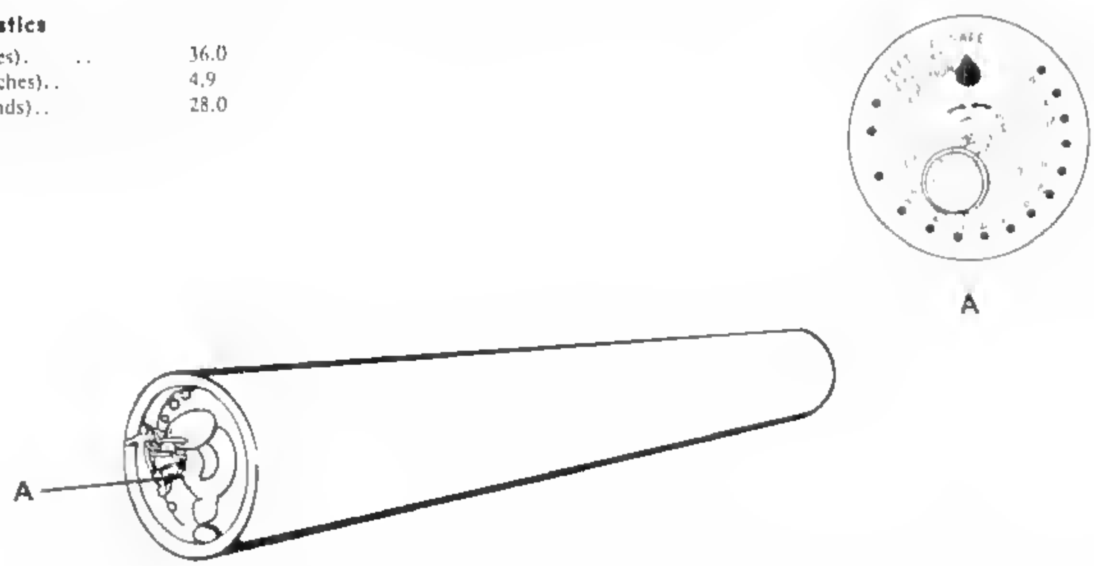


Figure 4-14. Mk 45 Mod 0 Aircraft Parachute Flare

4.6 LUU-2A/B, -B/B AIRCRAFT PARACHUTE FLARE

4.6.1 Description. The LUU-2A/B, -B/B aircraft parachute flare (APF) (Figure 4-15) is used for nighttime illumination of surface areas in search and attack operations and was designed to replace the Mk 45 APF. The two variants, A/B and B/B, are compatible with both the SUU-25 F/A and 44/A flare dispensers.

Note

The LUU-2A/B is not authorized for shipboard operations.

The LUU-2A/B APF provides 300 seconds of 1,600,000 candlepower illumination. The flare components include a timer assembly, parachute suspension system, ignition system, and case-candle assembly. The timer that controls the free-fall distance to parachute deployment and flare ignition has 12 settings between 500 and 11,000 feet of fall and a SAFE setting position. The desired functioning delay is selected by positioning the timer knob to the appropriate setting. A parachute deployment force of 98 pounds is required to initiate the candle. Rate of descent is 8 feet/second.

The LUU-2B/B APF provides 240 seconds of 2,000,000 candlepower illumination. The flare components include a timer assembly, parachute suspension system, an out-of-line igniter, and the case assembly with a tamped candle. The timer that controls the free-fall distance to parachute deployment and flare ignition has a 250-foot setting for helicopter use and 13 other settings between 500 and 11,000 feet of fall and a SAFE setting position. The desired functioning delay is selected by positioning the timer knob to the appropriate setting. A parachute deployment force of 90 pounds is required to pull the slider assembly (out-of-line igniter) into line releasing the firing pin to initiate the pyrotechnic train and candle.

A steel lanyard extracts the timer knob on both variants of the flare when dispensed/released which allows the timer clock mechanism to function. At the end of the preset delay time, a spring ejects the timer and release mechanism from the flare housing which deploys the 18-foot cruciform parachute. Initiation of the candle subsequently takes place. At candle burnout, an explosive bolt severs one of the suspension cables causing the parachute to collapse and the flare remains to free fall to the ground thus clearing the airspace of any flare debris hazard.

Characteristics

Length (Inches)	36.0
Diameter (Inches)	4.9
Weight (Pounds)	30.0

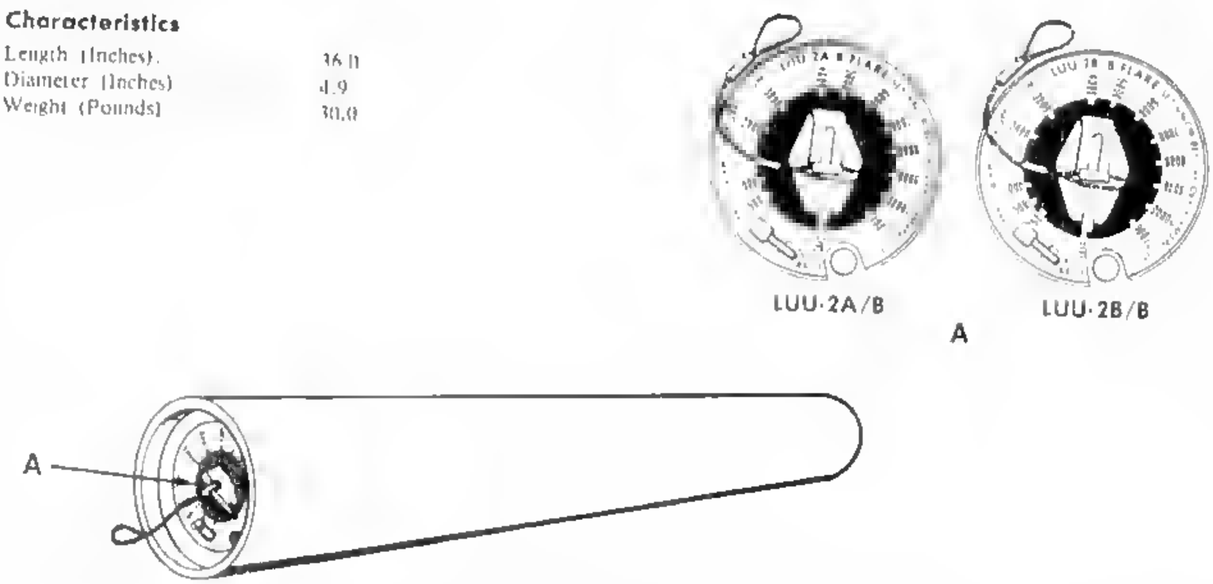


Figure 4-15. LUU-2A/B, -B/B Aircraft Parachute Flare

CAUTION

Flares released from SUU-25 F/A, SUU-44/A dispensers require straight and level delivery. Refer to Appendix A, External Stores Limitations Table, for additional restrictions.

4.6.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

4.6.3 Delivery Procedures (SUU-25 F/A, SUU-44/A)

1. Station mode select — FIRE

2. MASTER ARM — ON

3. To release flares — DEPRESS BOMB RELEASE BUTTON

4. To secure, MASTER ARM — OFF

5. Station mode select — OFF.

4.7 SUU-25 F/A DISPENSER

4.7.1 Description. The SUU-25 F/A dispenser (Figure 4-16) is a reusable four-tube launcher capable of carrying and ejecting rearward eight LUU-2A/B or B/B aircraft parachute flares. The ability of the dispenser to launch one flare at a time doubles its operational capability in comparison to the SUU-44/A dispenser.

Each of the four launching tubes accommodates two parachute flares. A flare adapter kit must be installed on each flare prior to being inserted into the launching tube. A nose cone is used to reduce drag and protect the breech cap electrical assembly cables. Eight breech and four loading/unloading caps are located on the front of the dispenser. A SAFE-ARM stepper-switch and a safety switch controls and safes the electrical circuitry of the dispenser. Pivotable retaining links with shear pins secure each flare in the launching tubes until ejection takes place.

The first release pulse steps the stepper-switch from ARM to position 1 initiating the first impulse cartridge. Gas from the fired cartridge is routed to the expansion area in front of the rear flare of the number one launching tube and exerts force against the flare causing the shear pin of the aft retaining link to shear releasing the link and allowing the flare to be ejected.

The launcher tube arming hook assembly strips the flare adapter kit arming cap that retains the flare timer knob which initiates the flare delay ignition sequence. The next release impulse steps the stepper-switch to the next position and fires the impulse cartridge of the forward flare of the launching tube that was previously fired. Sequence of the ejection events are identical to the first flare release. The third release pulse steps the stepper-switch to the rear flare of the next launching tube.

WARNING

Remain clear of aft end of dispenser when cartridges are installed. Ejection forces are capable of propelling a flare to a distance of 50 feet.

Refer to Appendix A, External Stores Limitations Table, for carriage and dispensing restrictions.

4.7.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	107.0
Diameter (Inches)	14.0
Weight (Pounds)	
Empty	260.0
Loaded	490.0

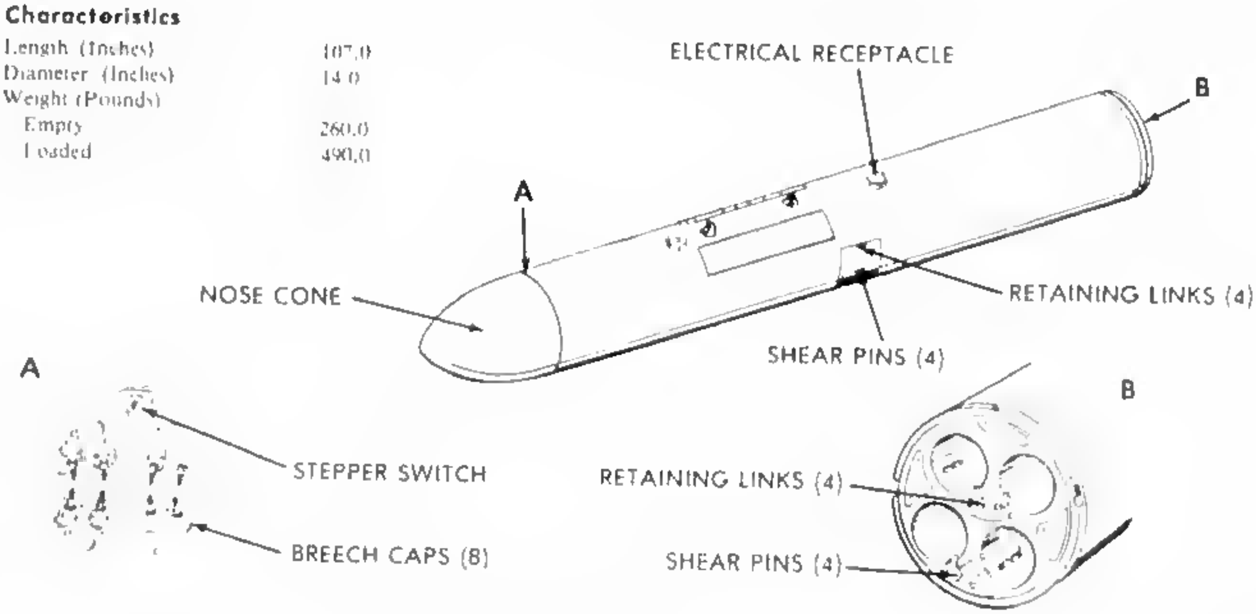


Figure 4-16. SUU-25 F/A Dispenser

4.8 SUU-44/A DISPENSER

4.8.1 Description. The SUU-44/A dispenser (Figure 4-17) is a reusable four-tube launcher capable of carrying and ejecting rearward eight Mk 45 Mod 0/LUU-2A/B, -B/B, parachute flares.

Each of the four launching tubes accommodates two parachute flares. A drogue tray must be installed on each store prior to insertion into the launching tube. A nose fairing is used to reduce drag and protect the breech cap electrical assembly cables. Four breech caps are located on the front of the dispenser. A safety switch safes the electrical circuitry of the dispenser. Pivotable shear latches with shearpins secure each loaded launching tube until ejection takes place.

The first release pulse initiates the impulse cartridge of number one launching tube. Gas from the fired cartridge fills the expansion chamber in front of the forward store, exerting force against both stores and causing the shear pin of the aft shear-latch assembly to shear, releasing the latch and allowing both and stores to be ejected. The airstream strips the drogue tray from the stores, initiating the flare delay ignition sequence or rotochute deployment. The next release impulse steps an internal stepper-switch to fire the impulse cartridge of the second tube. Sequence of ejection events are identical to the first launching tube.

WARNING

Remain clear of aft end of the dispenser when cartridges are installed. Ejection forces are capable of propelling a store to a distance of 50 feet.

Refer to Appendix A, External Stores Limitations Table, for carriage and dispensing restrictions.

4.8.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	110.0
Diameter (Inches)	14.0
Weight (Pounds)	
Empty	128.0
Loaded	352.0 - 368.0

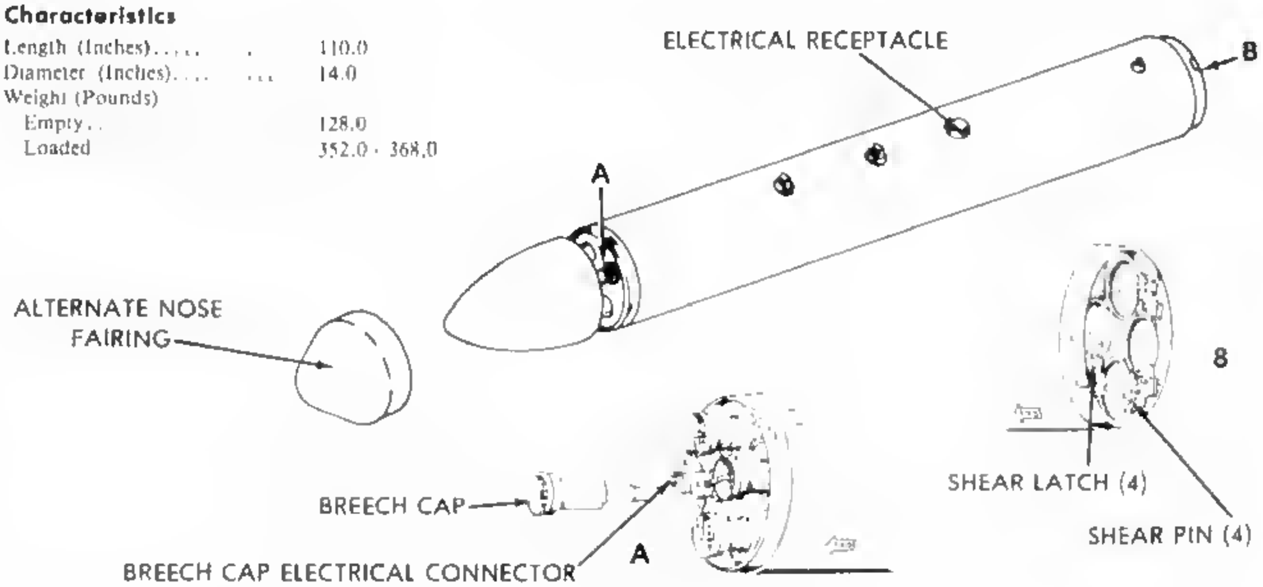


Figure 4-17. SUU-44/A Dispenser

4.9 MK 80-SERIES GENERAL PURPOSE BOMBS

4.9.1 Description. Low drag, general purpose (LDGP) bombs, Mk 80-series (Figure 4-18), are used extensively against a variety of targets. Their cases are relatively light and approximately 45 to 50 percent of the complete weight is explosive. Although not intended for penetration of armor, the casing is sufficiently strong to provide good weapon penetration on soft to medium hard targets when using other than an instantaneous fuze functioning delay. When fuzed for instantaneous functioning, they provide good fragmentation for use against personnel and light equipment.

LDGP bombs are designed for both electrical and mechanical fuzing. Nose and tail fuze cavities are interconnected by an electrical cable with a fuze charging receptacle located between the two suspension lugs. Electrical fuzes may be installed in either cavity without an adapter booster. The OV-10 aircraft does not have electrical fuzing capability. Mechanical fuzes may be installed either in the nose or tail cavity with the addition of an adapter booster. Tail fuzing only requires the installation of a hardened noseplug to prevent weapon breakup at impact.

With the exception of the Mk 81, recent production LDGP bombs have a thermal protective coating. Provided thermally protected fuzes and adapter boosters are installed, this coating provides several minutes additional time before the bombs detonate or deflagrate (i.e., detonate low-order) during a fire. LDGP bombs without thermal protection are still available for use.

4.9.2 Conical Fins. Conical fins are used with all Mk 80-series bombs. The fin has an access cover for inspection of the tail fuze and has holes drilled for installation of the electrical fuze arming wire.

The BSU-33A/B conical fin assembly is the replacement for the MAU-93 conical fin. It is similar in appearance to the MAU-93 fin and is designed for use with the Mk 82 GP bomb. Several modifications have been made to increase weapon roll control and stability which enhance target impact accuracy at high- and low-speed deliveries. The increased fin size and off-set angle to the fore and aft axis of the fin assembly, in addition to wedge plates attached to the outboard trailing edge of each fin, provide the enhanced flight characteristics. Also, a singular quick-attach device that replaces the multiple allen set-screws used for bomb body attachment reduces weapon assembly time and effort.

4.9.3 Retarding Fins. Mk 81 and 82 bombs can be configured with retarding fins that enable them to be delivered in the high or low drag mode. In the high drag mode, the impact angle is increased, which provides greater weapon effectiveness in low-level deliveries. The increased bomb to aircraft separation afforded by the high-drag fins permits the use of short fuze arming times.

Mk 14 fins are used with the Mk 81 and Mk 15 fins are used with Mk 82 bombs. The fins are actuated by the withdrawal of a fin release wire that is normally attached to the bomb rack arming solenoid to provide an in-flight option regarding the selection of the high or low drag release mode. Some fuzing applications require the use of an interlock arming wire that is connected between the fin and nose fuze to ensure that the nose fuze will not arm unless the fins have been deployed.

WARNING

See Appendix A, External Stores Limitations Table, General Notes, for current Mk 14/15 fin restrictions.

4.9.4 Limitations. Additional information on use and application of LDGP bombs is found in paragraph 4.24.2 and JMEM.

WARNING

Although an LDGP bomb can be released safe and will theoretically dud at impact, a high-order detonation is possible. Therefore, all normal release restrictions (i.e., minimum release altitudes, safe separation, etc.) must be observed when jettisoning.

4.9.5 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

4.9.6 Bomb and CBU Drop Procedures

1. Sight reticle brightness knob — AS DESIRED
2. FIL SEL switch — NO. 1 or NO. 2
3. Sight depression — AS REQUIRED

Characteristics	MK 81	MK 82	MK 83
Length (Inches)			
Conical	76.0	90.0	119.0
Retard	76.0	90.0	N/A
Explosive Weight (Pounds)	100.0	192.0	445.0
Diameter (Inches)	9.0	11.0	14.0
Suspension (Inches)	14.0	14.0	14.0
Total Weight (Pounds)			
Conical	260.0	531.0	985.0
Conical (TP)	N/A	544.0	1000.0
Retard	305.0	565.0	N/A
Retard (TP)	N/A	578.0	N/A

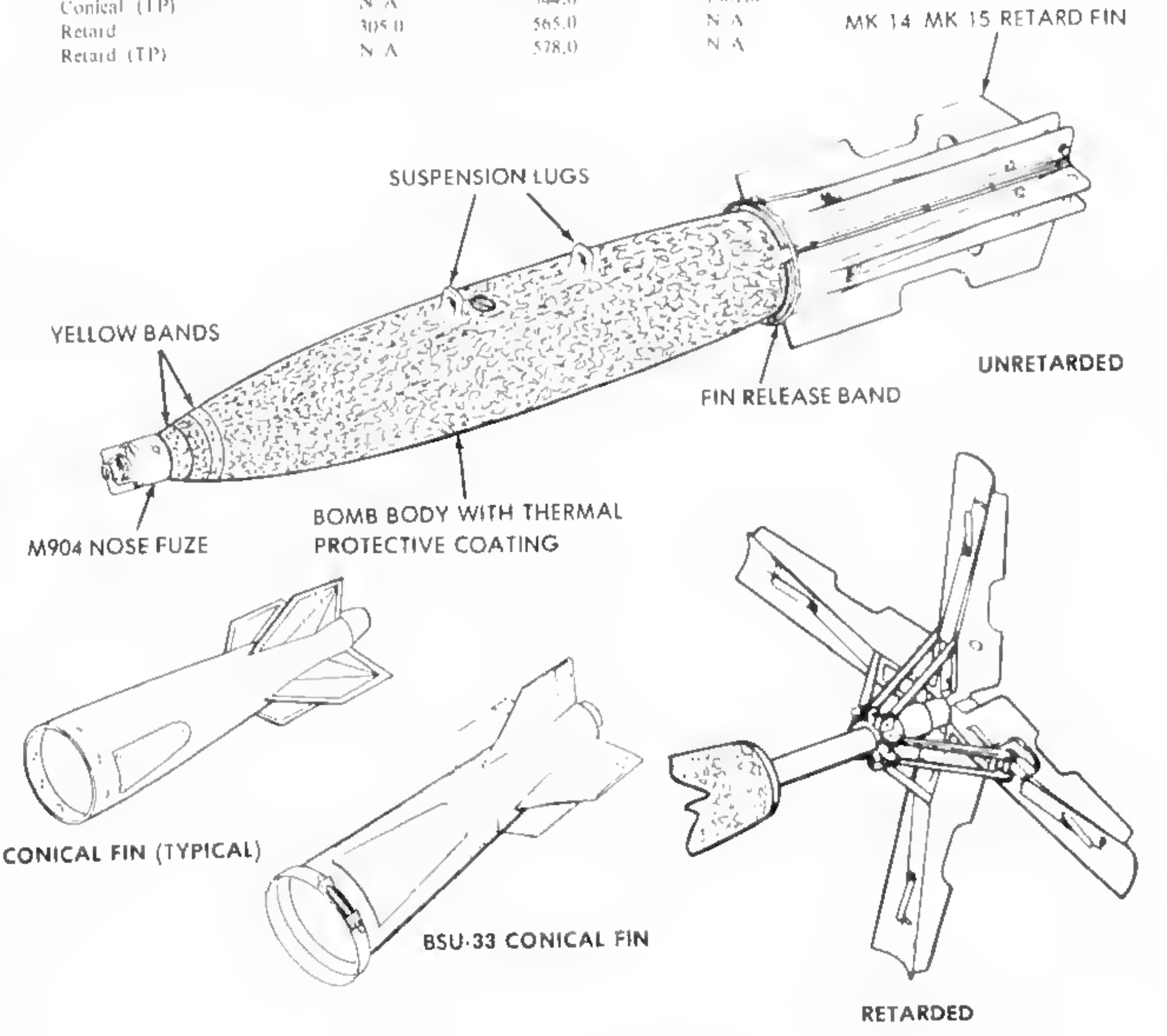


Figure 4-18. Mk 80-Series GP Bomb

4. BOMB-FLARE ARM switch — AS BRIEFED (NOSE & TAIL or TAIL)

5. STATION MODE SELECT switches — DROP

6. MASTER ARM switch — ON

7. To release — DEPRESS BOMB BUTTON

8. To secure, MASTER ARM switch — OFF

9. STATION MODE SELECT switches — OFF.

4.10 BDU-45/B PRACTICE BOMB

4.10.1 Description. The BDU-45/B practice bomb (Figure 4-19) was designed to simulate Mk 80-series GP bombs in low-/high-drag configurations. It is identical to the Mk 82 GP with the exception of an inert filler and provisions for spotting charges for target impact spotting/fuze functioning indication.

The BDU-45/B contains an internal cable assembly connecting the nose/tail fuze cavities for use of electrical fuzes/VT elements. Spotting is accomplished by the use of an electrical fuze (nighttime) or electrical fuze and two CXU-4/B spotting charges (daytime). Two spotting charge receptacles, 180° apart, are located on the aft bomb body just forward of the fin attachment point.

Detonation of the electrical fuze booster ruptures the spotting charges that create a white cloud and indicate fuze functioning and weapon impact point. The fuze booster produces sufficient flash for nighttime use without installation of the spotting charges.

For those aircraft (e.g., OV-10) that do not have an electric fuzing capability, a Mk 89 spotting charge adapter can be installed in the tail fuze cavity. A Mk 4/CXU-3A/B signal cartridge is installed in the Mk 89 adapter that expels smoke/flame for impact marking.

4.10.2 Fins. Mk 82 GP conical/retard (i.e., MAU-93 and BSU-33/Mk 15) fins are used to satisfy requirements for either low-/high-drag configurations. The Mk 15 fins are actuated by the withdrawal of a fin release wire that is normally attached to the bomb rack arming solenoid to provide an in-flight option of release modes.

4.10.3 Limitations. Refer to Appendix A, External Stores Limitations Table, for any additional carriage, release, and jettison requirements.

4.10.4 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	
Conical	90.0
Retard	90.0
Diameter (Inches)	11.0
Suspension (Inches)	14.0
Total Weight (Pounds)	
Conical	531.0
Retard	565.0

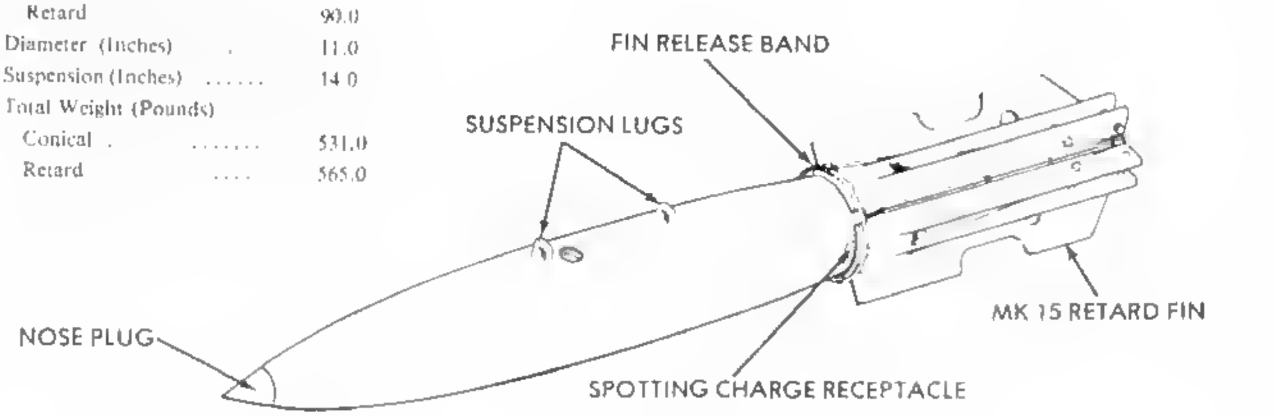


Figure 4-19. BDU-45/B Practice Bomb

4.11 MK 77 FIRE BOMB

4.11.1 Description. The Mk 77 fire bomb (Figure 4-20) is a thin-skinned, unstabilized container filled with a gelled fuel (fire bomb mix). Lack of stabilizing fins ensures that it tumbles, impacts, and ruptures in a trajectory that maximizes the dispersal of the 71 gallons of fire bomb mix. Fuzes and igniters are used to ignite the combustible filling.

The Mk 77 filler holes are 31° down the side of the container and provide the primary fuzing configuration. Alternate fuzing configuration is accomplished by the igniter wells located on the nose and tail bulkheads. The M918 fuze with the Mk 273 Mod 0 igniter is used as the primary fuzing configuration. The AN-M173A1 fuze and AN-M23A1 igniter are used as the alternate fuzing configuration. Refer to paragraph 4.25, M918/AN-173A1 Mechanical Impact Fuze, for additional information on fire bomb fuzes.

The elliptical burn pattern for low-level releases at speeds of 400 to 500 KIAS is approximately 50 feet in width and 250 to 300 feet in length. Temperature at the center of the pattern is approximately 1,300 °F. Burn pattern data for low-speed releases is not available.

Fire bombs are most effective when released in pairs at flightpath angles shallower than -30° where the bombs fall short of the target by at least one-half the effective pattern length. Steeper than -30° release will increase impact angles and decrease the elliptical burn pattern area. Manual release data of Mk 77 delivery are designed to put fire bombs on target center. The pilot must compensate for one-half pattern length short delivery.

WARNING

- The top of the fireball reaches approximately 250 feet AGL and burn duration is 15 to 30 seconds. Trailing aircraft should take appropriate interval.
- Fire bombs must be released armed or jettisoned. Because of residual explosive vapors they are not to be emptied and reused.

Refer to Appendix A, External Stores Limitations Table, for carriage and release restrictions.

4.11.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	81.2
Diameter (Inches)	18.6
Weight (Pounds)	520.0
Suspension (Inches)	14.0

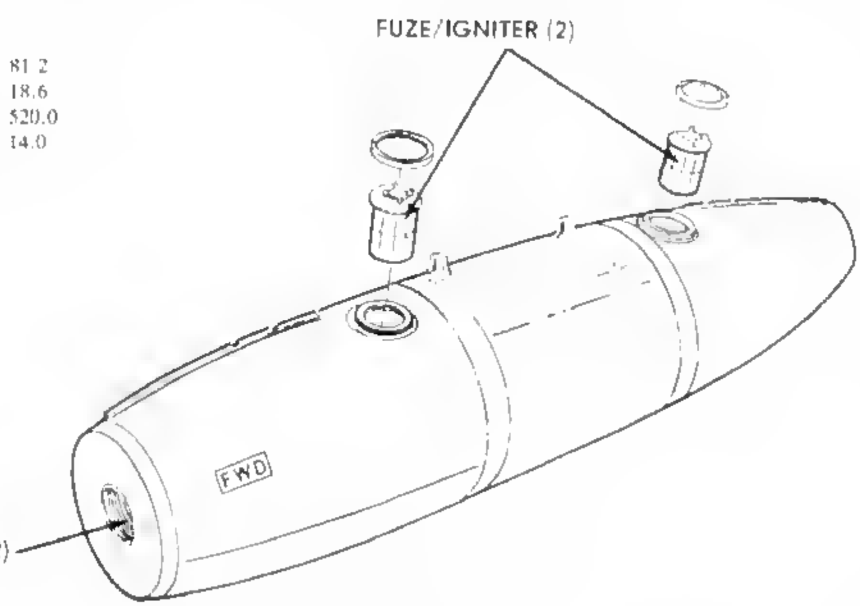


Figure 4-20. Mk 77 Fire Bomb

4.12 CBU-55A/B, -/B FUEL-AIR EXPLOSIVE (FAE)

4.12.1 Description. The CBU-55A/B, -/B FAE (Figure 4-21) is designed as a free-fall unguided weapon to be carried on low-speed aircraft that can be used against a variety of targets. It is effective against defensive positions, light material targets, clear foliage, booby-trapped areas, and for clearing helicopter landing zones. The primary damaging mechanism is the relatively long duration of overpressure, roughly equivalent to three Mk 82 (500 pound) bombs.

Both Mods (-A/B, -/B) of the CBU-55 FAE are received in an all-up round configuration and consist of a SUU-49A/B or -B dispenser, FMU-83/B mechanical time fuze that opens the dispenser at a preselected time, and three BLU-73A/B or -/B FAE bomb canisters. The CBU-55A/B FAE is an improved version of the CBU-55/B. Operationally, they are identical.

4.12.2 SUU-49A/B, -B Dispenser. The SUU-49A/B, -/B dispenser is an aluminum aerodynamically shaped cylinder equipped with a nose fairing, strong back, hard shell support area, fuze arming wire, four folding fins, a removable rear bulkhead, and an explosive communication link assembly. The Mod A/B dispenser also has a thruster mechanism that allows deployment of the two upper fins after release. After release, the fuze functions at its preselected time, initiating the explosive communication link and the mild detonating charge which removes the rear bulkhead assembly. Removal of the rear bulkhead assembly causes extraction and deployment of the stabilizer (drag parachute) attached to the aft BLU-73 bomb. Drag forces on the stabilizer extract the aft bomb and subsequently each bomb canister.

A fuze arming wire is installed in a conduit that is slotted (Mod A/B) at various intervals to allow positioning of the arming wire extractor to correspond with the placement of the arming solenoids on different suspension equipment. Mod A/B also has a thruster mechanism arming wire that is positively armed to the suspension equipment when used. The fuze arming wire extractor for the Mod B is fixed and not adjustable. Some aircraft configurations require that certain fins be deployed during loading. Both Mods of the dispenser allow for manual deployment of all four fins.

4.12.3 FMU-83/B Mechanical Time Fuze. Fuze function time settings, from 1.0 to 9.7 seconds, must be set prior to flight. The SAFE/ARMED status of the CBU-55 FAE can be checked by viewing the fuze safe/arm indicator through a view port in the fuze cover or after removal of the cover. The fuze is armed if the letter A is visible in a field of red. A green field surrounding the time setting numbers or a green field with the words NOT SET displays a safe condition. Refer to paragraph 4.26 for additional data on the FMU-83/B mechanical time fuze.

WARNING

CBU-55 Mods are not authorized for shipboard use. FMU-83/B fuzes will arm at release speeds of 75 KIAS and do not meet necessary safety standards.

4.12.4 BLU-73A/B, -/B Fuel-Air Explosive Bomb Canister. The BLU-73 Mods FAE bomb canister is a steel cylinder containing ethylene oxide. A contact fuze is located on the forward bulkhead and a stabilizer (drag parachute) on the aft bulkhead. A burster charge extends through the center of the canister and, when initiated by the contact fuze, it disperses the ethylene oxide, creating an aerosol cloud. Two cloud detonators installed in the sides of the bomb canister, opposite each other, are also ejected from the canister and detonate the aerosol cloud after a preset delay, creating the high overpressure.

The bomb canisters have a degree of target discrimination that allows them to penetrate light foliage without detonating. The fuze operational cycle commences when the bomb canister first enters the airstream. An extendable standoff probe extends immediately (Mod B), or after 2.2 seconds (Mod A/B), which detonates the bomb canister 4 feet above the surface of the target. If the standoff mode fails, an inertial backup system initiates the bomb canister. Some canister fuzes have a self-destruct device that will detonate the canister burster charge 2 minutes after impact. The self-destruct feature will function in water to depths of 30 feet.

Aerosol cloud formation is most effective when the impact angle of the bomb canister approaches 90°. The inertial backup system detonates the bomb canister if the impact/speed is insufficient for normal detonation. However, overall effectiveness is considerably degraded.

Refer to Appendix A, External Stores Limitations Table, for carriage and release restrictions.

Characteristics	CBU-55A/B, -B
Length (Inches)	90.5
Diameter (Inches)	14.0
Loaded Weight (Pounds).	512.0 - 520.0
Suspension (Inches).	14.0
Number of Bombs.	3

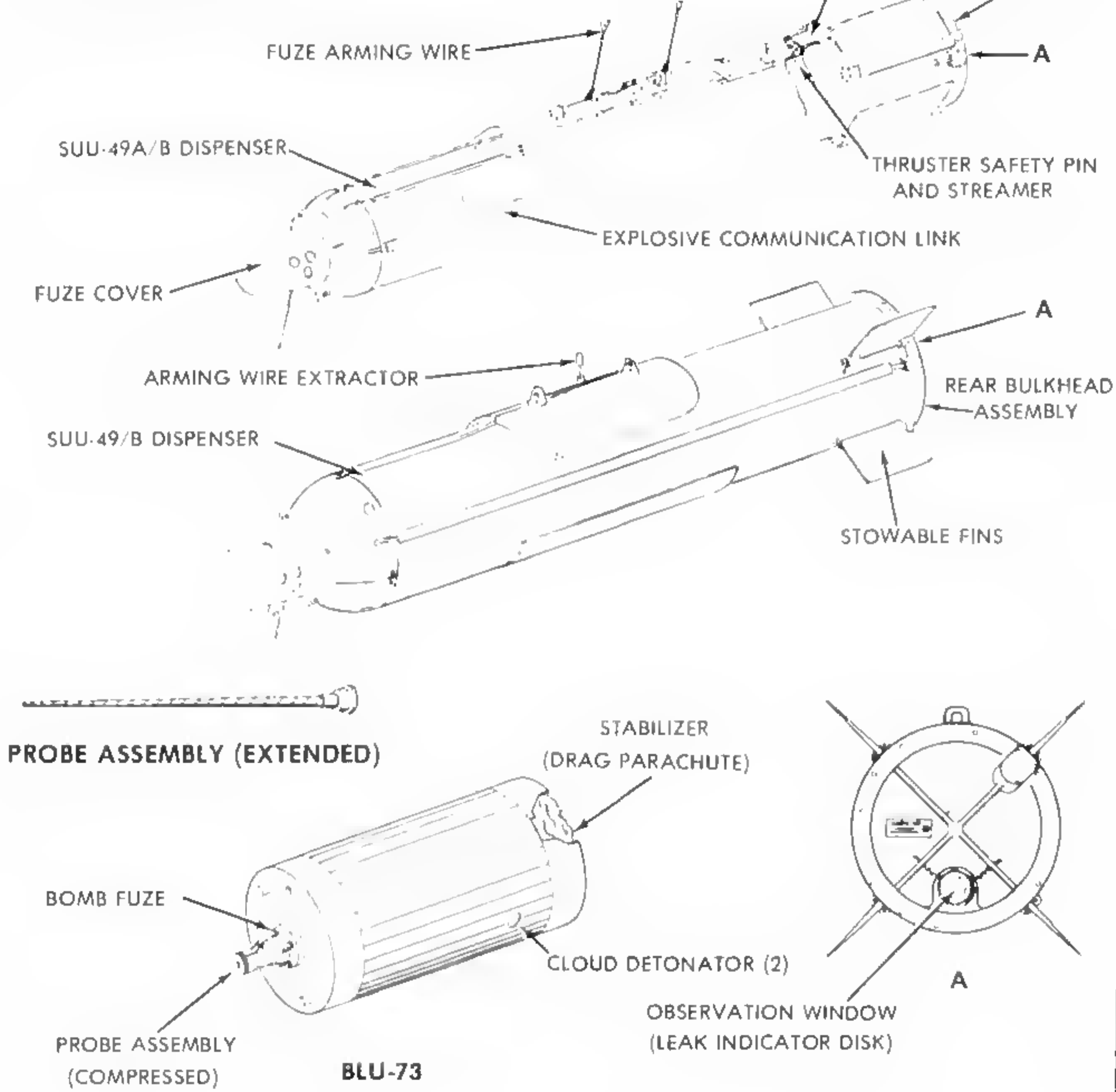


Figure 4-21. CBU-55A/B, -B, Fuel Air Explosive Bomb Cluster (FAE)

Refer to the Joint Munitions Effectiveness Manual (Air-to-Surface), Weapons Characteristics (JMEMs), for additional information concerning weapon application.

4.12.5 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

4.12.6 CBU Drop Procedures

1. Sight reticle brightness knob — AS DESIRED
2. FIL SEL switch — NO. 1 or NO. 2
3. Sight depression — AS REQUIRED
4. BOMB-FLARE ARM switch — AS BRIEFED (NOSE & TAIL or TAIL)
5. STATION MODE SELECT switches — DROP
6. MASTER ARM switch — ON
7. To release — DEPRESS BOMB BUTTON
8. To secure, MASTER ARM switch — OFF
9. STATION MODE SELECT switches — OFF.

4.13 MK 76 MOD 5 PRACTICE BOMB

4.13.1 Description. The Mk 76 practice bomb (Figure 4-22) is designed to simulate low-drag, free-fall weapons. It is comprised of a teardrop-shaped, cast-metal bomb body assembly with a bore tube for installation of a signal cartridge, a Mk 1 firing pin, and a screw-in single suspension lug. Impact initiates the Mk 4 or CXU-3A/B signal cartridge that expels smoke/flame from the bore tube for impact marking.

Note

The CXU-3A/B signal cartridge is for day use ONLY.

4.13.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	24.7
Body Diameter (Inches)	4.0
Weight (Pounds)	24.55
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

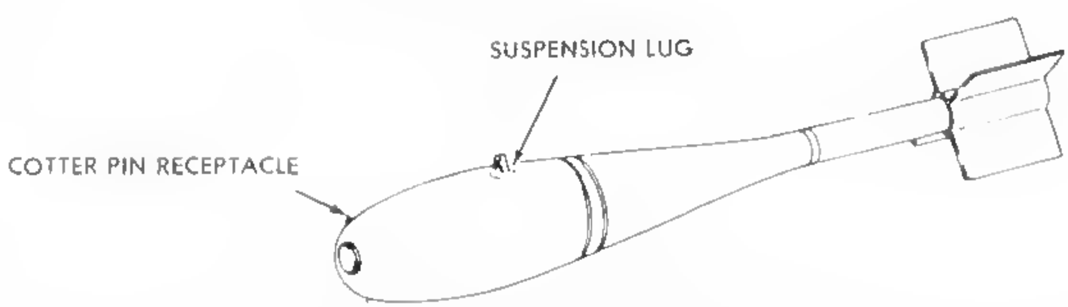


Figure 4-22. Mk 76 Mod 5 Practice Bomb

4.14 BDU-33D/B PRACTICE BOMB

4.14.1 Description. The BDU-33D/B is an Air Force designed practice bomb (Figure 4-23) used to simulate low-drag, free-fall weapons. It is similar in appearance and construction to the Mk 76 Mod 5 practice bomb. It is comprised of teardrop-shaped, cast-metal bomb body assembly with a bore tube for installation of a signal cartridge, a firing pin assembly, and a screw-in single suspension lug. The firing pin assembly that is extremely sensitive to pressure has provisions for safing by the use of a safety block which is removed after loading. Impact initiates the Mk 4 or CXU-3A/B signal cartridge that expels smoke/flame from the bore tube for impact marking.

Note

The CXU-3A/B signal cartridge is for day use ONLY.

4.14.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	23.19
Body Diameter (Inches)	4.0
Weight (Pounds)	25.0
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

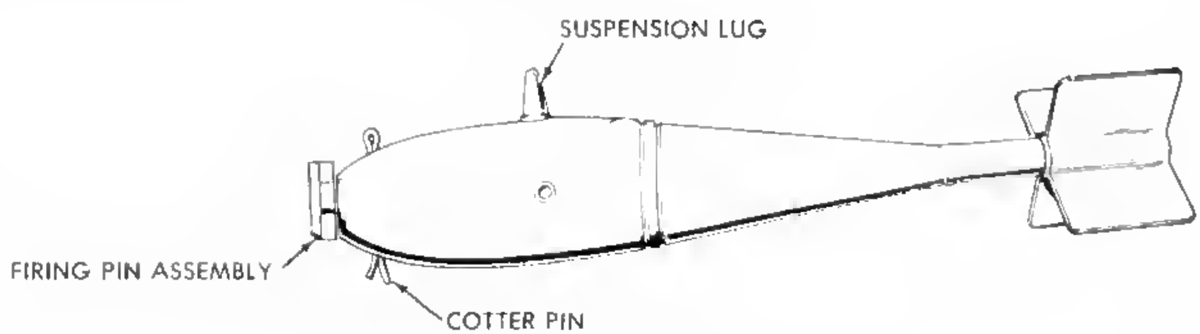


Figure 4-23. BDU-33D/B Practice Bomb

4.15 MK 106 MOD 5 PRACTICE BOMB

4.15.1 Description. The Mk 106 practice bomb (Figure 4-24) is designed to simulate a high-drag nuclear weapon or underwater mine or ADSID. It is comprised of a cylindrical bomb body assembly with a bore tube for installation of a signal cartridge, a screw-in firing device, and a spring-loaded retractable suspension lug. The screw-in firing device has provisions for safing by installing a safety pin. Impact initiates the Mk 4 or CXU-3A/B signal cartridge that expels smoke/flame from the bore tube for impact marking.

Note

The CXU-3A/B signal cartridge is for day use ONLY.

4.15.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics	Mod 5
Length (Inches)	21.12
Body Diameter (Inches)	3.87
Weight (Pounds)	5.13
Suspension . . .	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks.	Blue body with white lettering

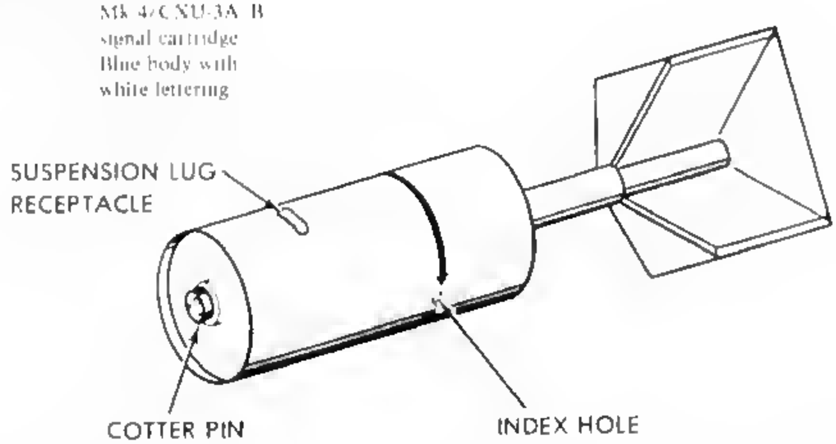


Figure 4-24. Mk 106 Mod 5 Practice Bomb

4.16 BDU-48/B PRACTICE BOMB

4.16.1 Description. The BDU-48/B practice bomb (Figure 4-25) is designed to simulate Mk 80-series LDGP bombs and DSTs released in the high-drag mode. It is similar in appearance and construction to the Mk 106 Mod 5 practice bomb. Its additional weight provides for a more stable release, better trajectory, and improved accuracy. It is comprised of a bomb body assembly with a bore tube for installation of a signal cartridge, a Mk 1 firing pin, and a spring-loaded retractable suspension lug. Impact initiates the Mk 4 or CXU-3A/B signal cartridge that expels smoke/flame from the bore tube for impact marking.

Note

The CXU-3A/B signal cartridge is for day use ONLY.

4.16.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	21.0
Body Diameter (Inches)	4.0
Weight (Pounds)	10.0
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

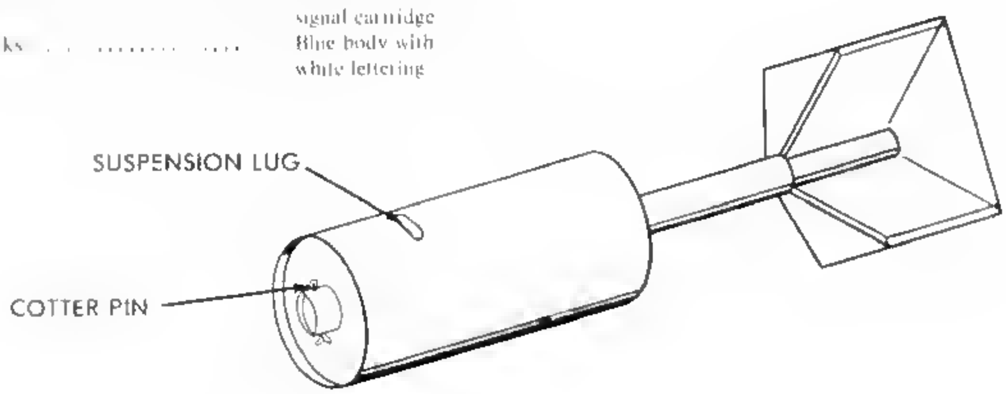


Figure 4-25. BDU-48/B Practice Bomb

4.17 TACTICAL AIRCREW COMBAT TRAINING SYSTEM POD (TACTS/AIS)

4.17.1 Description. The TACTS/AIS pod (Figure 4-26) is a subsystem of the advanced tactical aircrew combat training system developed to improve aircrew proficiency by transmitting altitude, velocity, acceleration, angular rate data, weapon status data, aerological sensor data, and responses to interrogation to a range ground station. This information is correlated and displayed in real time as it occurs and is recorded for the post-mission debrief.

The total system (air and ground subsystems) supports aircrew training in missile envelope boundaries (AIM-7 Sparrow/AIM-9 Sidewinder) and to repeatedly observe the results of simulated missile firing against manned high performance aircraft under realistic but controlled engagement conditions. It also enables aircrews to observe the results of operations (AGM-45 Shrike) against ground target threats (SAMS) and no-drop bomb scoring and mining operations.

The TACTS/AIS pod is physically similar to the AIM-9 Sidewinder and is compatible with all aircraft with LAU-7/A launcher capability. Operation of the pod is accomplished by utilizing aircraft ac and dc power through the launcher umbilical hookup connector.

Refer to Appendix A, External Stores Limitations Table, for authorized versions of the TACTS/AIS pod that are cleared for carriage.

4.17.2 Training Modes. The TACTS/AIS pod has five modes of operation that enable aircrew training to be accomplished in a logical sequence of progression in acquisition of combat skills. One or all five modes can be used during a given exercise depending on the programming of the ground station. Modes 1 and 2 are based on the aircraft being within rule-of-thumb missile and firing boundaries/envelopes. Modes 3, 4, and 6 use real-time missile simulations for providing realistic instruction and ACM tactics and missile capabilities/PK probabilities. Modes 1 and 3 are considered nonfiring modes that provide a continuous tone when the aircraft is within the proper envelope. Modes 2, 4, and 6 are firing modes and require a trigger squeeze to initiate envelope calculations or missile simulations.

4.17.3 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics

Length (Inches)	138.0
Diameter (Inches)	5.0
Weight (Pounds)	72.0

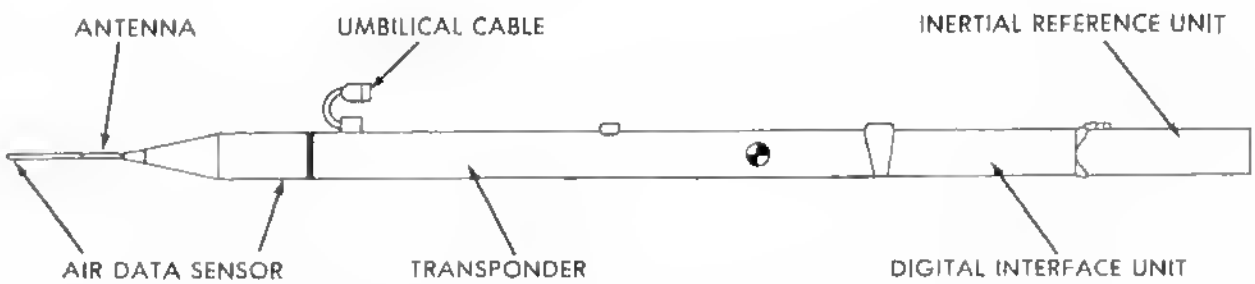


Figure 4-26. Tactical Aircrew Combat Training System (TACTS/AIS POD)

4.18 AIR-DELIVERED SEISMIC INTRUSION DETECTOR (ADSID III S/N)

4.18.1 Description. The ADSID III S or N (Figure 4-27) is an air-deployed, expendable, camouflaged, noncommandable sensor. It is intended to detect personnel and vehicle movement and is deployed without a parachute, implanting (except antenna) in the Earth's soil on impact.

Useful life is approximately 120 days. Sensor activation is accomplished at impact. After a 5- to 7-second delay all electrical circuits are activated. The sensor contains an FM transmitter tuned to one of several preselected channels. The antenna is a monopole or whip type, 21 inches in length. Ground plane radials are attached to improve antenna performance.

The sensor has an internal disabling circuit to render the transmitter inoperative. The disable function can be initiated by any one of the following: low battery voltage, improper implant (angle greater than 67° (±5°) from vertical), and tampering or attempting disassembly after activation. The sensor also contains an end-of-life timer that disables the transmitter after a preselected time.

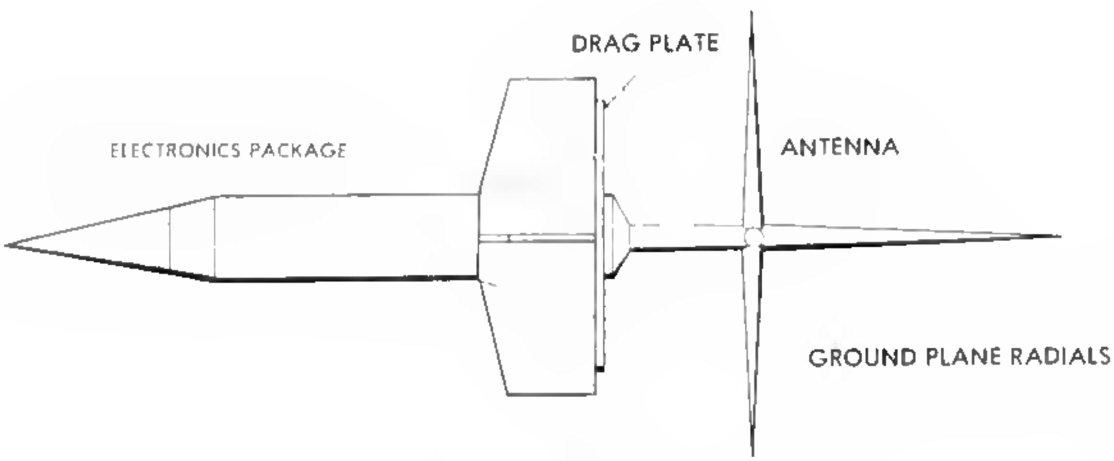
The ADSID III (N) has a folding fin detachable afterbody (DAFT) that is used to allow for variations of soil density. Sensor impact in relatively soft soil will allow the sensor body to penetrate below the surface while the aft plate and antenna remain on the surface connected by a trailing cable. The ADSID III (S) has a fixed fin drag plate without DAFT.

The ADSID III S or N can be released at speeds up to 250 KIAS. Release at speeds below 150 KIAS may not produce sufficient dynamic pressure to erect the ADSID III (N) drag brakes (fins). Consideration of the implant angle (less than 60° from the vertical for both sensors) as well as air load for drag brake opening (ADSID III (N)) must be given to determine proper release altitude and airspeed conditions. Additionally, soil hardness must also be considered for implant of ADSID III (S). ADSID III (S) may be released at altitudes provided down to 250 feet AGL.

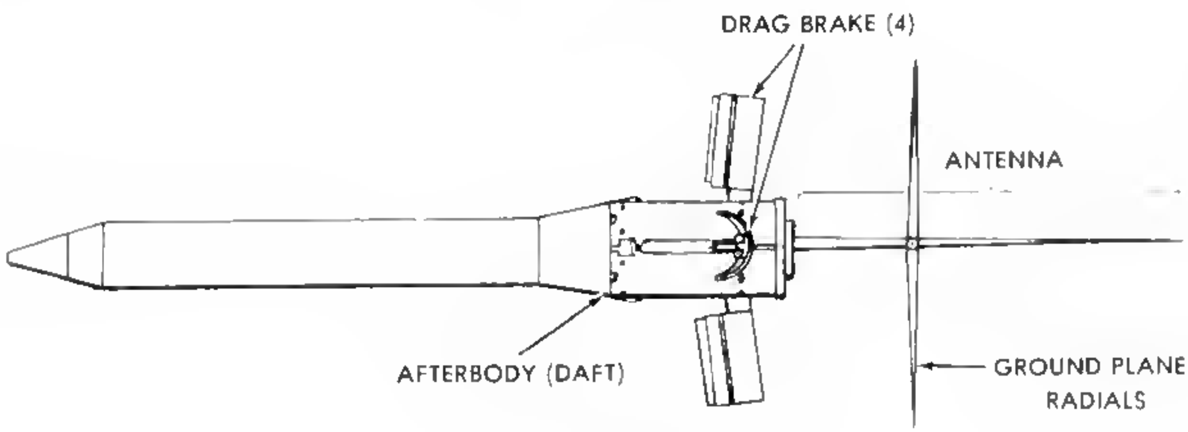
Refer to Appendix A, External Stores Limitations Table, for carriage and release restrictions and NWP 55-6-OV10A/D Volume II, Chapter 6 for delivery requirements.

4.18.2 Preflight Checks. Refer to NWP 55-6-OV10A/D PG (NAVAIR 01-60GCB-1T(B)) Tactical Manual Pocket Guide for current preflight checks.

Characteristics	ADSID III (S)	ADSID III (N)
Length (Inches) (Including antenna)	36.0	59.0
Diameter (Inches)	9.0	5.0
Weight (Pounds)	14.0	37.2
Detection Radius (Feet)	500.0	500.0



ADSID III (S)



ADSID III (N)

Figure 4-27. Air-Delivered Seismic Intrusion Detector (ADSID III S/N)

4.19 BOMB FUZING DISCUSSION

4.19.1 Introduction. Selection of the fuze type to ensure proper parameters (arming time/functioning delay) is absolutely essential for the safety of the delivery aircraft and for the effectiveness of the mission. Weapon kill mechanisms vary widely (e.g., high explosive for blast, overpressure, and fragmentation, napalm for fire, and cluster munitions for fragmentation, shaped-charge penetration or hypervelocity impact) and some weapons may be configured differently to satisfy varied employment roles (e.g., bombs as general purpose bombs or destructors). Consequently, it is necessary to maintain a number of different types of fuzes in the stockpile, and the peculiar operating characteristics of each impose varying delivery requirements and restrictions.

Fuzes may be divided into general categories: electrical or mechanical. Each has its own advantages and disadvantages.

Note

The OV-10 aircraft is NOT equipped with the necessary electronics required for electrical fuzes.

Mechanical impact fuzes DO NOT normally early burst (i.e., detonate) at or shortly after completion of the arming time cycle. Because of exposed vanes and arming wires, mechanical fuzes are subject to various delivery and carriage speed restrictions. In shallow or graze angle impacts, mechanical impact fuzes MAY NOT OPERATE.

Aircraft rearming or turnaround time is not a function of fuze type or category. Bombs equipped with mechanical fuzes are normally fuzed after aircraft loading. In addition to installing the fuze, an arming wire must be connected/routed to the proper rack solenoid, to the high drag fin if required, and both routed and installed in the fuze vane.

4.19.2 Operating Principle-Mechanical Fuzes. Most current mechanical fuzes contain the same basic elements and operate on similar principles.

4.19.3 Arming. Arming is accomplished via a vane/impeller. This vane/impeller is held stationary before weapon release by an arming wire/safety clip that is attached/routed to an arming solenoid on the bomb rack. During an armed weapon release, the arming wire/safety clip is withdrawn, and the vane/impeller is unlocked and driven by the airstream, providing the mechanical energy needed to operate the fuze arming/functioning mechanism.

If the weapon is to be released armed, the appropriate bomb rack arming solenoid is energized, thus ensuring withdrawal/retention of the arming wire. At release, the arming wire/safety clip is withdrawn from the fuze vane/impeller, permitting it to rotate in the airstream. This rotation drives a gear train that removes certain safety locks in the fuze and aligns the explosive train. When this occurs, the fuze is considered armed and ready to function (fire). The gear train mechanism is designed to provide a finite delay after separation from the aircraft. In all impact fuzes, this time is referred to as an arming time that can only be preflight selected in some fuzes. In time fuzes, a functioning time is selected and arming occurs after a predetermined part of this functioning interval has elapsed.

4.19.4 Functioning. In impact fuzes, the firing pin is driven into the detonator on weapon impact. This in turn initiates the fuze booster explosive that initiates the main bomb explosive charge. For a nose fuze, longitudinal deformation or crushing of the fuze body is the action that moves the firing pin. In tail fuzes, inertia moves the firing pin. A functioning delay time can be provided by an internal pyrotechnic delay to allow target penetration prior to detonation. Longer delays up to several hours are provided in one LONG DELAY TIME fuze (i.e., Mk 346) used for area denial purposes. Selection of the proper functioning delay time is necessary for maximum weapon effectiveness against a target. Some recommended delay times (for target effectiveness) are presented later in this section and a thorough discussion of functioning delay time versus target type is presented in the Joint Munitions Effectiveness Manual (JMEM).

In time fuzes, the firing pin is released by a timing mechanism at a preset time. This time is preflight selectable. Since time fuzes are employed in dispenser weapons, the time selected is a function of the delivery tactic to be employed, submunition characteristics (arming requirements), and the desired impact pattern.

4.19.5 Mechanical Fuzes in Current Inventory. Mechanical fuzes in the current inventory will include the types discussed in the following paragraphs.

4.19.6 M904 Series. The M904 series is the most widely used fuze for Mk 80-series bombs. The arming time is preflight selectable and the functioning delay time (M9 element) is installed during fuze installation. This fuze is used in the nosewell of Mk 80-series bombs.

It can be utilized in both the low-drag and the high-drag configuration. It is NOT RECOMMENDED for use against extremely hard targets (i.e., runways, dams, or bunkers). M904-series fuzes are available in both the thermally protected and nonthermally protected versions.

4.19.7 Mk 346 Long-Delay Fuze. This is a tail fuze driven by an external arming device (vane assembly) and is used to provide a delayed detonation (preflight selectable) from 1/2 hour to 33 hours after impact. The fuze is used primarily for area denial and interdiction purposes and may be delivered in conjunction with destructor weapons for additional countermeasure protection.

4.19.8 FMU-83/B Mechanical Time Fuze. This fuze is used to control the opening of the CBU-55 dispenser weapon. A vane enables the arming mechanism. A timing (clockwork) mechanism then completes the arming cycle and, at a preset functioning time after weapon release, an explosive charge is initiated resulting in dispenser opening. This fuze is limited to dispenser applications and cannot be used in high-explosive bombs.

4.19.9 Fire Bomb Fuzing. The M918/AN-M173A1 fuzes have omnidirectional firing mechanisms that will function irrespective of the weapon impact orientation. They employ a white phosphorous or similar igniter to ignite the gel after rupture of the fire bomb canister.

4.19.10 Carriage and Release Speed Restrictions. Individual fuze data sheets in this section list the maximum and minimum carriage and release speeds imposed by the fuze itself. The maximum speed may be further reduced by the weapon configuration or by airframe restrictions. These additional restrictions are found in the External Stores Limitations Table, Appendix A, or in the Weapon Delivery/Description sections of this manual. If no other speed restrictions apply, then the fuze imposed limits are the limiting speed restrictions.

Carriage speed restrictions are usually imposed by the fuze arming wire configurations but in certain cases are the result of airstream buffeting/vibrations that occur to the weapon.

Release speeds are imposed by the aerodynamic characteristics of the fuze. In some cases, release at speeds higher than authorized can damage the arming vane or cause faulty or erratic arming. In general, maximum carriage and release speeds are determined by safety considerations, but in some cases, reliability is the governing factor. Weapon effectiveness can also limit release speeds; excessive release speeds can cause the weapon to penetrate too deeply into the ground to be effective or the resulting high velocity/impact shock can cause damage to the fuze/arming device.

Minimum release speeds are sometimes imposed. These speeds are necessary to ensure proper arming/functioning of the fuze.

4.19.11 Safe-Jettison. To safe-jettison bombs with mechanical fuzes, the bomb rack arming solenoids are left in the unenergized condition, allowing the arming wire/swivel assembly to be released and remain with the fuze and weapon at release. It is important to recognize that NO WEAPON can be safe-jettisoned with 100 percent certainty that there will be no detonation. With mechanical fuzes, it cannot always be assured that the arming wire/swivel assembly will be released by the unenergized arming solenoid. If a weapon with an unarmed fuze impacts with sufficient velocity on a hard target, detonation can still occur, with possible bomb fragment damage to the delivery aircraft, if the aircraft is below the minimum authorized release altitude for that particular weapon and delivery tactic. Therefore, weapons should be safe-jettisoned over soft ground or water at low speeds and at an altitude that is greater than the fragmentation envelope for that weapon. This is particularly important for bombs configured with mechanical nose fuzes.

4.19.12 Arming Wires. Loss of an arming wire in flight will probably result in a mechanical fuze arming while the weapon is still on the bomb rack. If it is an impact fuze, when the bomb is released it could detonate dangerously close to the aircraft if it is subjected to bomb-to-bomb collision. If it is a time fuze, it could result in dispenser opening while still attached to the aircraft. The submunitions would now be a hazard to the delivery aircraft. Arming wires are secured by safety clips at the fuze arming vane, or by clamps which are integral to the fuze itself. Details of arming wire installation appear in the Weapons/Stores Loading Manuals/Checklists/NWP 55-6-OV10A/D Tactical Manual Pocket Guide. Additional information on preflight checks is provided in each fuze description.

Check that all warning tags and safety pins or wires have been removed from the weapon/fuze prior to launch. Any remaining tags or pins could possibly cause the weapons/fuze to malfunction/dud.

4.19.13 Guidelines for Selection of Fuze Arming Times. Operations employing in-flight option of delivery mode (high drag versus low drag, high-altitude straight-and-level versus dive, etc.) present a potential hazard because of the possibility that an arming time may be selected that is unsafe for the type of delivery maneuver actually being used. When using in-flight delivery options, weapons will be more effective, safe, and reliable if the following points are thoroughly understood.

Guidelines:

1. Most importantly, always refer to the charts/data pertaining to authorized fuze arming times/maximum stick lengths (Figure 4-39) for the specific delivery mode and maneuver to be used.

2. Care must be exercised to select the proper fuze arming time if both safety and reliability are to be achieved. Stick length and flightpath angle must be considered in determining the proper arming time.

3. Additional precautions must be observed during high-drag weapon deliveries and are summarized below:

(a) Delivery of high-drag weapons in dives of less than 20° or from altitudes below 500 feet will result in very shallow bomb impact angles that could result in weapon duds. Shallow bomb-impact angles also increase the probability of an ensuing ricochet; under these conditions, bombs may ricochet back into the air and travel and additional distance down range, detonating on a following impact.

(b) A high-drag fin malfunction (separation of the fin from the bomb or failure of the fin to open) together with the short arming times and low release altitudes normally authorized for high-drag deliveries presents a critical safe-escape situation at weapon impact. This situation becomes more critical as stick lengths increase. These hazards will be minimized if an arming wire is utilized to interconnect the M904 nose fuze and the high-drag fin, thus assuring that the fuze will not be allowed to arm if the high-drag fin fails to open.

4.20 DUAL FUZING

A GP bomb may be fuzed with a combination of the M904 and Mk 346 fuzes to increase the number of weapon delivery options. The advantages of dual fuzing must be balanced against the added complexity of weapon assembly and loading, cockpit switchology, and the possible hazards to the delivery aircraft that could result from switchology errors.

Dual fuzing requires the pilot/aircrew to be knowledgeable of the correct weapon arming wire rigging and appropriate switchology required to obtain the recommended fuze for the target being attacked. Improper cockpit switchology could result in aircraft damage/loss or could result in the activation of the wrong fuze nullifying the weapons blast/destructive effects.

There is a minimum authorized arming time for each of the currently employed delivery tactics or maneuvers (i.e., level with/without a recovery maneuver; dive/high drag). Dual fuzing can provide weapon delivery flexibility.

4.21 GUIDELINES FOR SELECTION OF FUZE FUNCTIONING DELAY

The M904 fuze is limited to preflight selection (M9 element installation) of the functioning delay time. This delay time must be considered during the mission planning procedure.

Weapon effectiveness is directly related to the utilization of appropriate fuze function mode or functioning delay time. Studies have demonstrated that a weapon, that could produce 100-percent damage to a target when the proper fuze functioning delay was employed, could also produce as little as 1-percent damage if the wrong fuze functioning delay was used.

The following guidelines serve as a rule of thumb in the selection of the best function mode or functioning time so as to optimize weapon effectiveness against targets of opportunity. Refer also to Figure 4-28.

Note

> Certain targets require bomb penetration to maximize weapon effects. For these cases, the bomb should be fitted with a steel noseplug and fuze cavity liner to ensure structural bomb integrity at impact.

Guidelines:

1. The maximum crater diameter can be produced by using a 10- or 25-millisecond delay time. These delays are most effective in cratering reinforced runways, roads, or hard-packed soil, either dry or muddy. The 100-millisecond delay results in excessive penetration in most soils before bomb detonation, which tends to minimize cratering. On hard-packed soils such as roads or under runways, the weapon will come to a complete stop with very little penetration, so crater diameter will be the same irrespective of the functioning delay time actually used. For this type of target, the use of the 100-millisecond delay affords no improvement in target damage over a 10- or 25-millisecond delay.

2. A weapon will come to a complete stop and thus achieve maximum penetration at about 50 milliseconds after weapon impact. If maximum penetration is desired, the 100-millisecond functioning delay time should be selected. Maximum penetration is required for destruction of underground bunkers and storage tanks, buildings of more than two stories, and earth-covered hangars. Maximum damage can be inflicted upon bridge abutments and tunnels by the earth-shaking action resulting from deep penetration detonations.

3. The 10- or 25-millisecond delays are most effective against bridge spans, heavily constructed single-story buildings, stonework defenses, and railroad yards. Above-ground storage tanks and armored vehicles are most effectively destroyed by either an instantaneous or by a 15-millisecond delay, with the delay being more effective in the event of a direct hit.

4. With instantaneous functioning, fragmentation effects are maximized and cratering is limited because there is little weapon penetration. Therefore, targets that are protected by even a light surface covering will not be effectively damaged. On the other hand, aircraft parked in the open, radar vans, missile fire control equipment, unarmored vehicles, and personnel are good targets for an instantaneous surface burst. Above-ground storage tanks and armored vehicles can be damaged or destroyed by fragmentation from a near-miss surface burst.

The before mentioned guidelines hold true for all Mk 80-series bombs. While certain bombs are more effective against specific target types, these guidelines are all correct within the general range of effectiveness for the four available functioning options.

Refinements of this data are available in the Joint Munitions Effectiveness Manual (JMEM). Figure 4-28 is a summary and recommends what is considered the optimum functioning delay for several typical targets.

SUMMARY OF FUNCTIONING DELAY OPTIONS FOR BEST TARGET KILL PROBABILITY (TYPICAL)

Target		Preferred Functioning Delay Option	Alternate Delay Option
Tanks, armored vehicles	Near Miss	Inst.	----
	Direct Hit*	.010	.025
Jet Aircraft	On runway	Inst.	----
	Behind revetment	Inst.	----
Personnel in open		Inst.	----
Railroad	Rolling Stock	Inst.	----
	Yards, Tracks	.010	.025
Buildings	Single-Story	.025	.010
	Multi-Story	.100	.250
Bridges	Masonary	.100	.250
	Suspension	Inst.	.010
Tunnels, bunkers, underground storage tanks		.100	.250
Runways		.010	.025

*Probability of direct hit is substantially less than that for near miss.

Figure 4-28. Summary of Functioning Delay Options

4.22 M904-SERIES MECHANICAL NOSE FUZE

4.22.1 Description. The M904-series mechanical nose fuze (Figure 4-29) is authorized for use in Mk 80-series GP bombs. It is also used in M1A1 fuze extension (Daisycutter) to provide above ground detonation to minimize cratering and maximize fragmentation effects. An adapter booster has to be installed to provide mating of the fuze/fuze extension and bomb nose fuze well.

Nine preflight selectable arming delays, from 2 to 18 seconds in 2-second increments, are available and can be set into the fuze by means of an arming delay setting knob on the face of the fuze. Six M9 functioning elements are available; one nondelay (0.000-second INST) and five delay (0.01, 0.025, 0.05, 0.10, and 0.25 second) of which one must be present in the fuze prior to installation in the bomb. Fuzes are normally issued with either an M9 nondelay (0.000) or 0.025 element installed. If mission requirements dictate the use of another element, it must be so specified on the operational load plan.

The M904 E2/E3/E4 fuzes are functionally the same with the exception that the E3/E4 are more sensitive against soft targets such as mud and water, particularly in the high-drag delivery mode. The M904E2 is unsuitable against hard targets (concrete) at high impact velocities and may detonate instantaneously at impact regardless of the M9 element installed. The M904E4 differs from the E3 only in that it has a fire-retardant molded-rubber sleeve over the fuze body to increase the resistance to cookoff during a fire.

M904E4 fuzes were developed for use with thermally protected adapter boosters and thermally protected Mk 80-series GP bombs to increase cookoff time in the event of accidental engulfment by fire. This fuze can be used with nonthermally protected adapter boosters and GP bombs only if E2/E3 fuzes are not available. However, the E4 fuze by itself will not increase the cookoff time unless used in combination with a thermally protected adapter booster and bomb. The use of an E2/E3 fuze in a thermally protected bomb can, if the weapon is exposed to fire, result in a greater potential hazard than if these fuzes were used in a standard nonthermally protected bomb. The nonthermally protected fuze will react to the heat before the thermally protected bomb, and fuze functioning will cause the bomb to detonate high order. With nonthermally protected fuzes and bombs, the bomb main charge will normally react to heat first and produce a low-order explosive reaction. Identification of the thermally protected adapter booster is provided by the bold black letters THERMALLY PROTECTED on the forward collar face.

The SAFE/ARM status of the fuze was determined during fuze installation by the displays found in the two observation windows. Refer to NAVAIR 11-1F-2 or 11-5A-17 for details.

4.22.2 Applications and Restrictions. The M904-series fuze functions because of deformation or crushing of the vane and arming delay setting knob into the fuze body and is only sensitive to impacts that occur in a narrow cone along the bomb's longitudinal axis. At shallow impact angles, the fuze may not even contact the target mass. It should not be used for straight and level deliveries less than 500 feet or from dives of less than 20° (both common to high-drag deliveries).

The M904-series fuze may function instantaneously on impact with an extremely hard target such as a concrete runway, dam, or bunker, or the bomb itself may detonate because of these very severe impact conditions. The M904 fuze is not very effective when hard target penetration is desired.

Of the nine preflight selectable arming delays, the 2- and 4-second settings are authorized for highdrag deliveries only. The arming time that is authorized is a function of planned delivery speed and altitude. Refer to Figure 4-39, Authorized Fuze Arming Times/Maximum Stick Lengths charts, for various maneuvers and airspeeds.

The 2- and 4-second arming time settings are locked out so that a conscious effort is required to select either one of these settings. A stop screw located on the fuze body must be removed in order to select the 2- or 4-second arming delay settings. The stop screw must not be reinstalled after the arming delay has been set or the fuze will dud. The stop screw is not removed for any setting other than the 2- or 4-second arming time.

Safe separation between bomb and aircraft, for the shorter arming times, is obtained only if proper bomb retardation occurs. An arming wire is rigged to interlock the fuze and the high drag fin thus assuring that the fuze will not be allowed to arm if the high drag fin fails to open. This fuze interlock wire must be used whenever an M904 fuzed bomb is to be delivered in the high-drag configuration.

Characteristics

Type	Impact Mechanical - Nose
Limit Speeds	
Max Carriage...	475 KIAS
Max Release.	525 KIAS
Min Release....	175 KIAS
Arming Times....	2, 4, 6, 8, 10, 12, 14, 16, 18-seconds
Arming Time Tolerance	4, 6, 8, 10, 12, 14, 16, 18-sec nominal — ± 10% 2 sec nominal — - 10% + 20%
Functioning Times . .	0.000, 0.010, 0.025, 0.050, 0.100, 0.250-sec
In-Flight Options	None
Authorized Bombs .	All MK 80 Series GP (low/high drag configured)

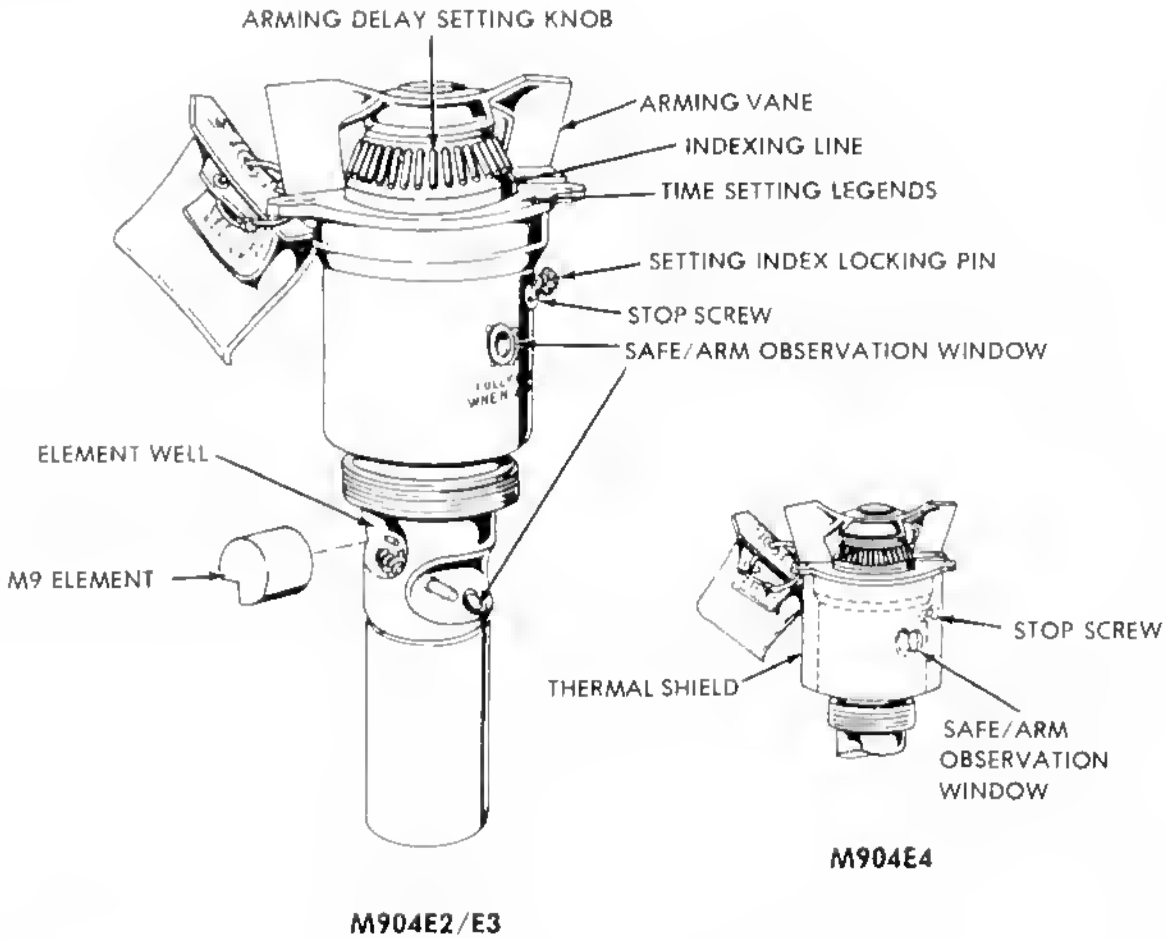


Figure 4-29. M904-Series Mechanical Nosefuze

Note

Buildup/loading procedures require the interlocking arming wire to always be installed.

An M9 nondelay (0.000-second INST) element must be installed when the fuze is used with an M1A1 fuze extension (Daisycutter).

The fuze arming time tolerance will not be maintained at release speeds below 175 KIAS. The arming time will probably exceed weapon time-of-fall and cause a dud.

Refer to Appendix A, External Stores Limitations Table, for any additional restrictions.

4.22.3 Preflight Checks

1. Fuze — SAFE
2. Fuze — SET
3. Safety wire/warning tags — REMOVED
4. Arming wire(s) installed in accordance with Pocket Guide/Weapons/Stores Loading Manual

4.23 M1A1 FUZE EXTENSION (DAISYCUTTER)

4.23.1 Description. The M904 fuze/M1A1 fuze extension (Figure 4-30) provides an above-the-ground detonation for Mk 80-series GP bombs. This fuzing configuration minimizes cratering and maximizes fragmentation effects against such targets as lightly armored equipment and exposed personnel.

The Daisycutter is an explosive-filled (Composition B) metal tube extension that transfers the M904 nose fuze firing train output to the adapter booster in the bomb. The M1A1 fuze extension is available in 18- and 36-inch lengths.

WARNING

Use of the M1A1 fuze extension degrades the improved cookoff characteristics provided by the thermally protected Mk 80-series GP bomb/M904E4 and M148E1 adapter booster combination in the event of a fire.

4.23.2 Applications and Restrictions. The fuze extension modifies the free-flight characteristics of the Mk 80-series GP bomb so that under certain release conditions there is increased risk of bomb-to-bomb or bomb-to-aircraft collisions with a resultant increased danger to the delivery aircraft. Refer to Appendix A, External Stores Limitations Table, for loading, carriage, release intervals, and jettison restrictions.

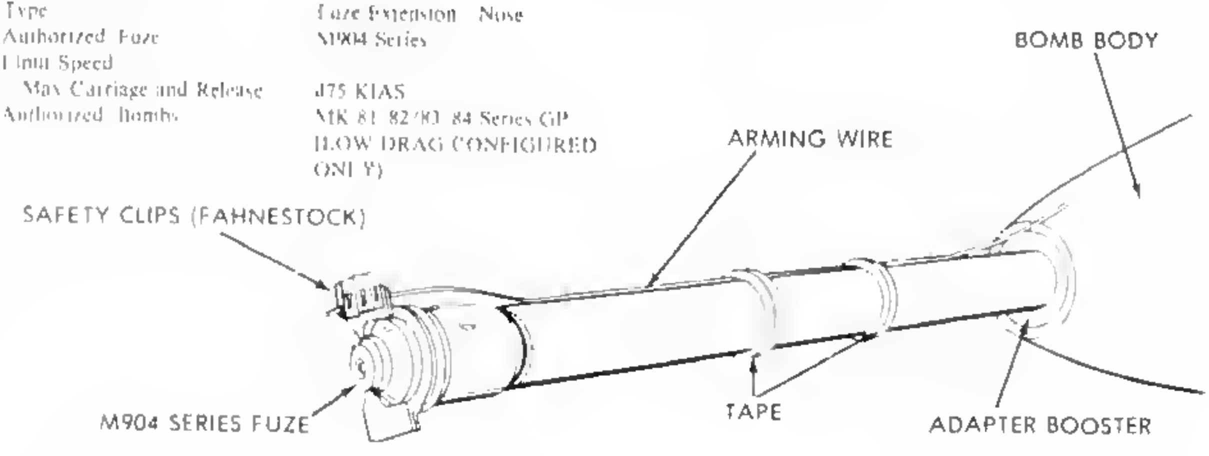
Note

- The M904-series fuze must have an M9 nondelay (INST) element installed to ensure maximum weapon effectiveness.
- The M1A1 fuze extension is not authorized for use in weapons configured with high-drag fins.
- M1A1/M904 series fuze combination is authorized with FAHNESTOCK clips for arming wire retention.

Delivery tactics that will ensure weapon impact at a relatively low speed and at the steepest possible angle are required. Shallow angle impacts not only nullify the desired fragmentation effects but may also cause shearing of the fuze extension from the bomb prior to detonation resulting in a weapon dud.

Characteristics

Type	Fuze Extension - Nose
Authorized Fuze	M904 Series
Limit Speed	
Max Carriage and Release	475 KIAS
Authorized Bombs	MK 81/82/83/84 Series GP (LOW DRAG CONFIGURED ONLY)



NOTE: 18-INCH EXTENSION USES ONLY ONE PIECE OF TAPE

Figure 4-30. M1A1 Fuze Extension (Daisycutter)

Because of the sensitivity of the Composition B filler, a bomb fuzed with an M1A1 fuze extension is not authorized for shipboard use or arrested landings. It is recommended that if an unsuccessful attempt has been made to release a weapon in flight, that it be jettisoned prior to landing.

4.23.3 Preflight Checks

1. Fuze — SAFE

2. Fuze — SET

3. Safety pin/wire/warning tags — REMOVED

4. Arming wire installed in accordance with Pocket Guide/Weapons/Stores Loading Manual.

4.24 MK 346 MECHANICAL IMPACT (LONG-DELAY) TAIL FUZE

4.24.1 Description. The Mk 346 fuze (Figure 4-31) is an impact, long-delay tail fuze authorized for use with the conical fin configuration of Mk 81-, 82-, 83-series GP bombs.

The Mk 346 fuze functioning delay is set into the fuze prior to installation of the fuze into the bomb. The range of the functioning time is from 30 minutes to 33 hours, which can be set in 15-minute increments.

After arming, a spring-loaded antiremoval cam impedes removal of the fuze and booster from the bomb fuzewell. The fuze does not contain a booby trap feature.

Two events are necessary to accomplish arming: air enabling and impact. The fuze is air enabled by a wind driven vane working through an arming assembly. These arming assemblies are designated Mod 1 (governed) or Mod 2 (direct drive). Direct drive is stenciled on the drive housing for ease of identification. The two arming assemblies (governed and direct drive) provide air enable times for the low-drag configuration as follows:

Mod 1.....1.5 to 2.0 seconds

Mod 2.....No less than 0.3 second

Once the fuze is enabled, impact will arm the fuze. Impact also initiates the long delay clock mechanism and causes the antiremoval feature to engage; the time setting mechanism is disengaged and locked, denying the enemy a means of countering the fuze by changing the time-to-detonation setting.

When the Mk 346 fuze is installed in a thermally protected bomb, it should be fitted with a thermal shield so that the fuze's resistance to cookoff is made comparable to that of the bomb. The shield also covers the aft exposed surface of the adapter booster.

4.24.2 Applications and Restrictions. The release parameters shown in Figure 4-31 for speed and altitude must be followed in order to ensure 90-percent operability. If tactics require it, these limits may be exceeded, but reliability will be degraded.

The restrictions on speed and altitude are necessary because the internal arming and timing mechanisms of the fuze are sensitive to impact velocity and angle. High release velocities/high release altitudes result in excessive impact shocks that may damage the timer and cause a dud. Minimum release speeds ensure that the weapon has sufficient velocity at impact so that the magnitude of the impact shock is sufficient to arm the fuze. Shallow angle impacts result in large side forces that will prevent fuze arming.

Because of this impact-sensitivity characteristic, fuze operability will be very doubtful against any water targets with depths over 20 feet or with a soft, muddy bottom. High reliability can be expected against any land target or mud or water targets providing that there is a firm bottom and the water depth is less than 10 feet. However, the speed and altitude restrictions in Figure 4-32 must be observed.

For hard targets, a steel noseplug and fuzewell cavity liner must be installed in the bomb nose fuzewell to prevent weapon breakup or warhead explosive charge deflagration on impact.

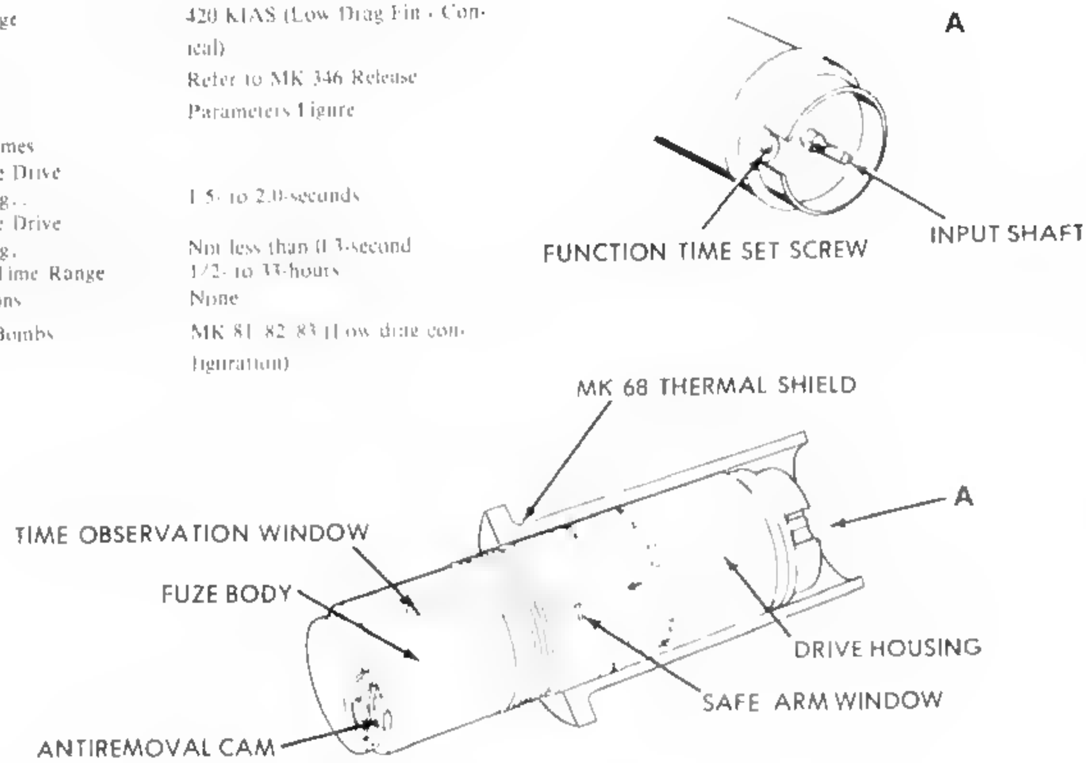
WARNING

Do not rely on the functioning delay of the Mk 346 fuze to provide safe escape. The weapon may detonate if it impacts with a hard target. Delivery restrictions are the same as for any Mk 80-series GP bomb of the same weight and configuration (low drag).

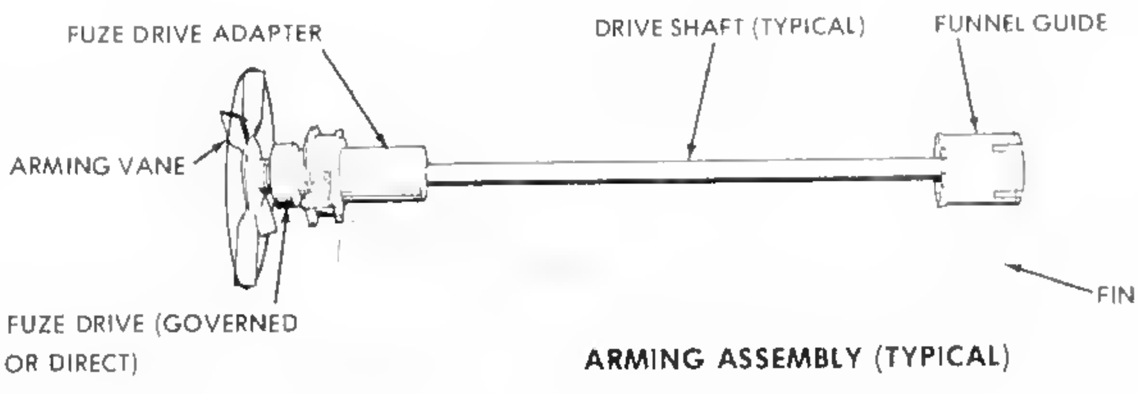
Refer to Appendix A, External Stores Limitations Table, for any additional restrictions.

Characteristics

Type	Impact (Long Delay) - Mechanical - Tail
Limit Speed	
Max Carriage	420 KIAS (Low Drag Fin - Conical)
Release	Refer to MK 346 Release Parameters Figure
Air Enable Times	
Mod 1 Fuze Drive	
Low Drag..	1.5- to 2.0-seconds
Mod 2 Fuze Drive	
Low Drag.	Not less than 0.3-second
Functioning Time Range	1/2- to 33-hours
Inflight Options	None
Authorized Bombs	MK 81, 82, 83 (Low drag configuration)



MK 346 FUZE



ARMING ASSEMBLY (TYPICAL)

Figure 4-31. Mk 364 Mechanical Impact (Long Delay) Tail Fuze

4.24.3 Preflight Checks

1. Arming vane — INSTALLED.

LOW DRAG DELIVERY ONLY	
RELEASE SPEED	
MAXIMUM	LBA
MINIMUM	200 KTAS
RELEASE ALTITUDE	
MAXIMUM	NONE
MINIMUM	1,000 FEET

Figure 4-32. Mk 346 Release Parameters

2. Secure/ warning tags — REMOVED.

3. Arming wire installed in accordance with Pocket Guide/Weapons/Stores Loading Manual

4. Ensure correct mod of arming mechanism is Installed.

4.25 M918/AN-173A1 MECHANICAL IMPACT FUZE

4.25.1 Description. The M918/AN-173A1 mechanical impact fuzes (Figure 4-33) are inertia-firing, multiposition fuzes that are used in fire bombs. The M918 is identical in external appearance to the AN/M173A1 except external markings are located on the flat surface between the vane and fuze body threads. They differ in booster size and functioning delay time. The M918 provides a 0.3-second delay after impact, and the AN/M173A1 functions instantaneously on impact.

WARNING

The two fuzes are not interchangeable and must only be used with their respective igniters or a weapon dud could result.

The M918 fuze is used with the Mk 273 Mod 0 igniter that contains magnesium-teflon powder and pellets, and the AN/M173A1 fuze is used with the AN/M23A1 igniter that contains white phosphorous (WP).

Both fuzes have in-line explosive trains. The term ARMING of these fuzes refers only to unlocking the impact sensing mechanism.

The impact sensing mechanism is unlocked (armed) by arming vane rotation, which is dependent on release speed. Approximate arming times (unlocking impact mechanism) are:

200 KIAS. . . . . .1.2 seconds

350 KIAS. . . . . .0.8 second

4.25.2 Applications and Restrictions. Fire bombs are always dual fuzed, with both fuzes being of the same type. The M918 fuze and Mk 273 igniter can only be used in the side wells of the Mk 77 Mod 4 fire bomb. The AN/M173A1 fuze and AN/M23A1 igniter combination is used only in the nose/tail wells of the Mk 77 Mod 4 fire bomb. The AN/M173A1 fuze M23A1 igniter combination is considered to be the alternate fuzing method.

Because of higher carriage speeds encountered with current aircraft, arming wire vibrations and whipping movement for nose and tail fuzed fire bombs can develop that could sever the arming wire securing the arming vane. For this reason, use the lower carriage and release speeds listed in Figure 4-33 for the AN/M173A1 fuze.

WARNING

Because of the in-line firing train of these fuzes, safe jettison cannot be assured. Severe shock can initiate the fuzes regardless of being released with the arming wires still installed.

Refer to Appendix A, External Stores Limitations Table, for any additional restrictions.

The gel mixture and target determines which fuze should be used.

Gelled JP-5 . . . . Land Target . . . AN/M173A1
Gelled AVGAS . . . Land Target . . . M918
MOGAS or JP-4 . . Water Target . . AN/M173A1

4.25.3 Preflight Checks

WARNING

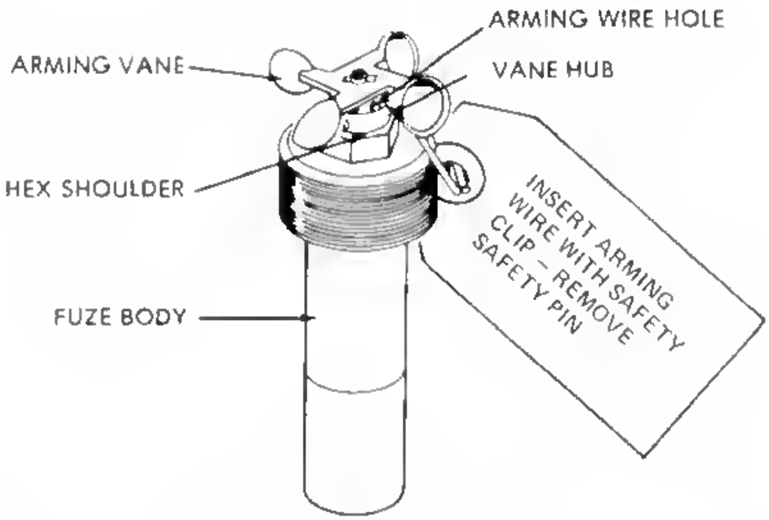
If clearance between the arming vane hub and hex shoulder exceeds one-eighth inch, the fuze impact sensing mechanism is considered unlocked (armed) and is extremely sensitive to shock/sudden movement.

1. Fuze — SAFE

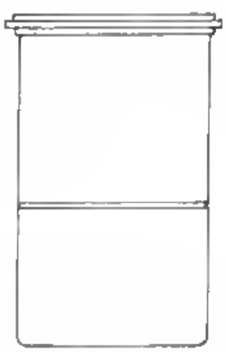
2. Safety pins/warning tags — REMOVED

3. Arming wires installed in accordance with Pocket Guide/Weapons/Stores Loading Manual.

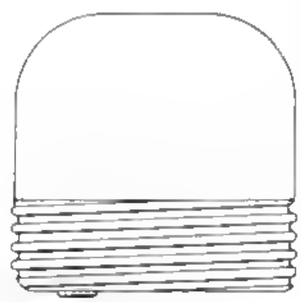
Characteristics	M918	AN/M173A1
Type . .	Impact-Mechanical	Impact - Mechanical
Location	Side Well	Nose/Tail Wells
Limit Speeds		
Max Carriage	475 KIAS	350 KIAS
Max Release	525 KIAS	450 KIAS
Arming Time(s)		
200 KIAS	1.2 seconds	1.2-seconds
350 KIAS	0.8-second	0.8-second
500 KIAS	0.6-second	0.6-second
Functioning Times	0.300-second	0.000-second
Inflight Options. . . .	None	None
Authorized Bombs	MK 77 Mod 4	MK 77 Mod 4
Igniter	MK 273 Mod 0	AN/M23A1



M918/AN-M173A1 FUZE



MK 273 MOD 0 IGNITER



AN/M23A1 IGNITER

Figure 4-33. M918/AN-M173A1 Mechanical Impact Fuze

4.26 FMU-83/B MECHANICAL TIME FUZE

4.26.1 Description. The FMU-83/B mechanical time fuze (Figure 4-34) is a universal dispenser fuze for slow speed aircraft and is currently used to initiate opening of the CBU-55 FAE weapon. The fuze is received preassembled in the weapon.

Note

> To ensure BLU-73 bomb canister arming, a 2.2-second time-of-fall is required after FMU-83/B fuze functioning.

The fuze has a time setting dial that must be set prior to flight. The preflight selectable-time range is from 1.00 to 9.70 seconds in 0.10-second increments.

The time setting observation window also incorporates a visible indication of the fuze SAFE/ARM condition. A SAFE condition is the desired set functioning time superimposed on a green background. An ARM/partially ARMED condition exists when a red background is visible in the observation window. Refer to Figure 4-34 for detailed indications.

4.26.2 Applications and Restrictions. The FMU-83/B mechanical time fuze will arm and reliably function at delivery speeds of 75 KIAS to 300 KIAS. Minimum release speed is 75 KIAS.

Certain early production FMU-83/B fuzes have an arrow decal on the timer-setter assembly. These fuzes can only be set by rotating the screw in a clockwise position in accordance with the decal. The screw on those fuzes without a decal may be rotated in either direction.

Refer to Appendix A, External Stores Limitations Table, for any additional restrictions.

4.26.3 Preflight Checks

1. Fuze — SAFE

2. Fuze function time — SET

3. Safety pin and warning tag — REMOVED

4. Arming wire installed in accordance with Pocket Guide/Weapons/Stores Loading Manual.

Characteristics

Type	Mechanical Time - Nose
Limit Speeds	
Max Carriage	450 KIAS
Max Release	300 KIAS
Min Release	75 KIAS
Functioning Time Range	1.0- to 9.7-seconds
Inflight Options	None
Authorized Bombs	CBU-55/B, -A/B, FAE

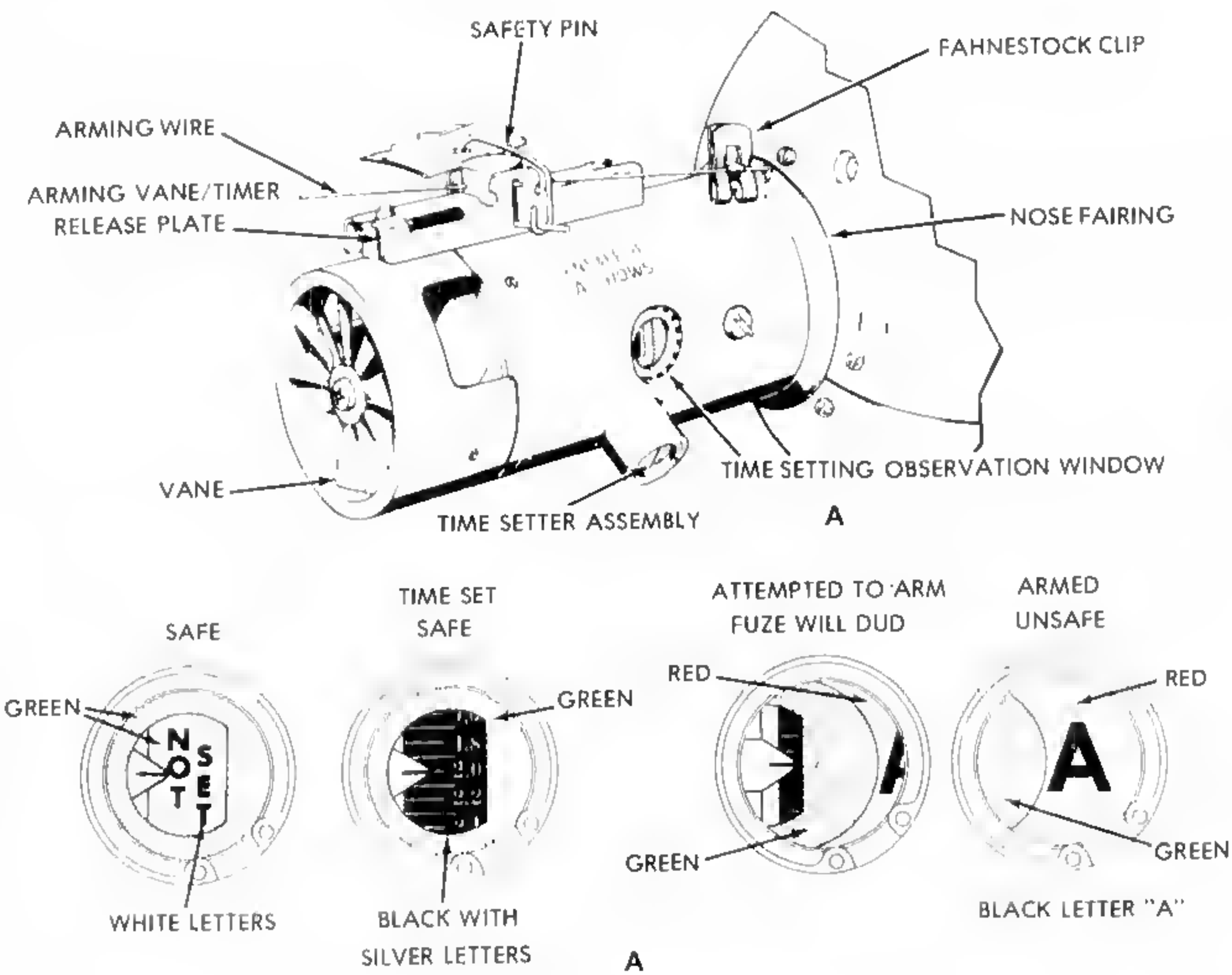


Figure 4-34. FMU-83/B Mechanical Time Fuze

4.27 ROCKET FUZING

4.27.1 General. Rocket fuzes are divided into three categories based on mode of functioning:

1. Impact
2. Time
3. Proximity.

Impact firing fuzes are referred to as point detonating (PD) or base detonating (BD) according to their location in the warhead. The Mk 191 fuze, that is permanently installed in the Mk 24 Mod 0 (GP) warhead is the only current base detonating fuze in use.

Time fuzes detonate/initiate the warhead at a preset time after rocket launch and motor burnout. The three time fuzes currently in use are the Mk 193, M442, and FMU-136/B that are installed in the Mk 33 Mod 1, M257, and Mk 84 Mod 4 (RR-184 A/L) warheads.

Proximity fuzes radiate an RF frequency at right angles to the warhead axis and upon receipt of a reflected RF energy (target reflection) initiate warhead detonation sequence. The insensitivity of the fuze allows ripple firing (salvo) of the rockets and precludes using the fuze for air-to-air missions. Water content of the target increases the magnitude of the target reflected signal, which results in a higher initiation height leading to warhead detonation. The fuze senses foliage and will initiate warhead detonation above the foliage with the burst height dependent on growth density and its moisture content.

4.27.2 Arming. Two types of arming mechanisms are used. One mechanism uses a combination of rocket motor acceleration integration/time for arming. This mechanism provides a safe separation distance between the delivery aircraft and rocket warhead by delaying the completion of the arming cycle for a specific period of time if the rocket motor maintains a minimum acceleration level. Approximately 20g's to 30g's of sustained acceleration for about 1 second are required for arming. Variation of arming distances should be anticipated because of manufacturing tolerance and temperature effects on the fuze mechanism.

The second type of mechanism employs acceleration/time integration to enable with actual arming occurring at motor burnout. Distance is determined by an acceleration time integration mechanism in the fuze, and time is determined by motor burnout/clock mechanism.

4.27.3 Safety. Rocket fuzes contain internal safety/arming devices to prevent arming for any condition other than the completion of a clean rocket launch. Delivery (launching) of airborne rockets within the appropriate release envelopes given for this aircraft should preclude possible damage to the aircraft.

Note

- As some fuzes have shorter arming distances/times, only those motor/warhead fuze combinations listed in the Warhead/Fuze Combination Charts (Figures 4-1 and 4-3) in the rocket descriptions are authorized for carriage/release.
- MIXING of VT and PD fuzes in the same 5.00-inch launcher is authorized if warheads are of the same type.

4.27.4 Rocket Fuzes. The following paragraphs provide a brief description of all currently authorized rocket fuzes (Figure 4-35). Refer to NAVAIR 11-1F-2 for detailed functioning information.

4.27.5 Mk 181 Impact (PD). The Mk 181 nosefuze was designed to be used only with the Mk 5 2.75-inch HEAT warhead. It will function against mild steelplate of 0.125-inch minimum thickness at impact angles between 0° to 60° perpendicular to the plate. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's in order to arm. Air travel to arm is approximately 330 to 660 feet.

4.27.6 Mk 352 Impact (PD). The Mk 352 nosefuze was designed to be used in either 2.75-inch/5.00-inch rocket warheads. It requires an adapter booster BBU-15/B for installation in 5.00-inch warheads. The fuze is sensitive to low angle impacts on all targets including water, and will function when it impacts 0.016-inch thick aluminum sheet at approach angles as small as 3° to 5°. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's minimum in order to arm. Air travel to arm is approximately 800 to 1,200 feet and time to arm is 1.07 to 1.36 seconds at 40g's.

4.27.7 FMU-90/B Impact (PD). The FMU-90/B nose fuze is identical in all respects to the Mk 352 fuze with the exception of a 0.05-second impact functioning delay time. It can also be used in most configurations as the Mk 352.

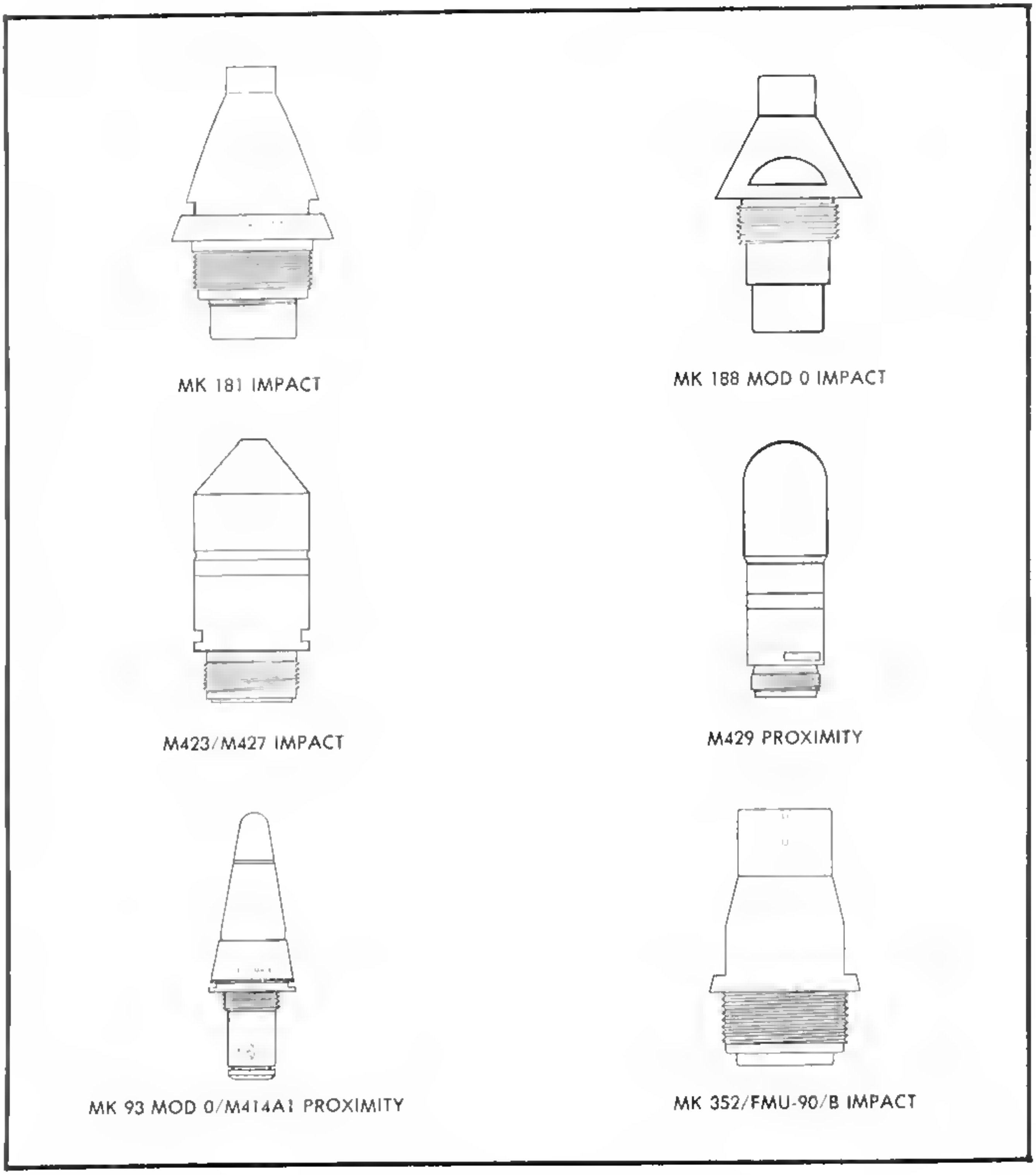


Figure 4-35. Airborne Rocket Fuzes (Sheet 1 of 2)

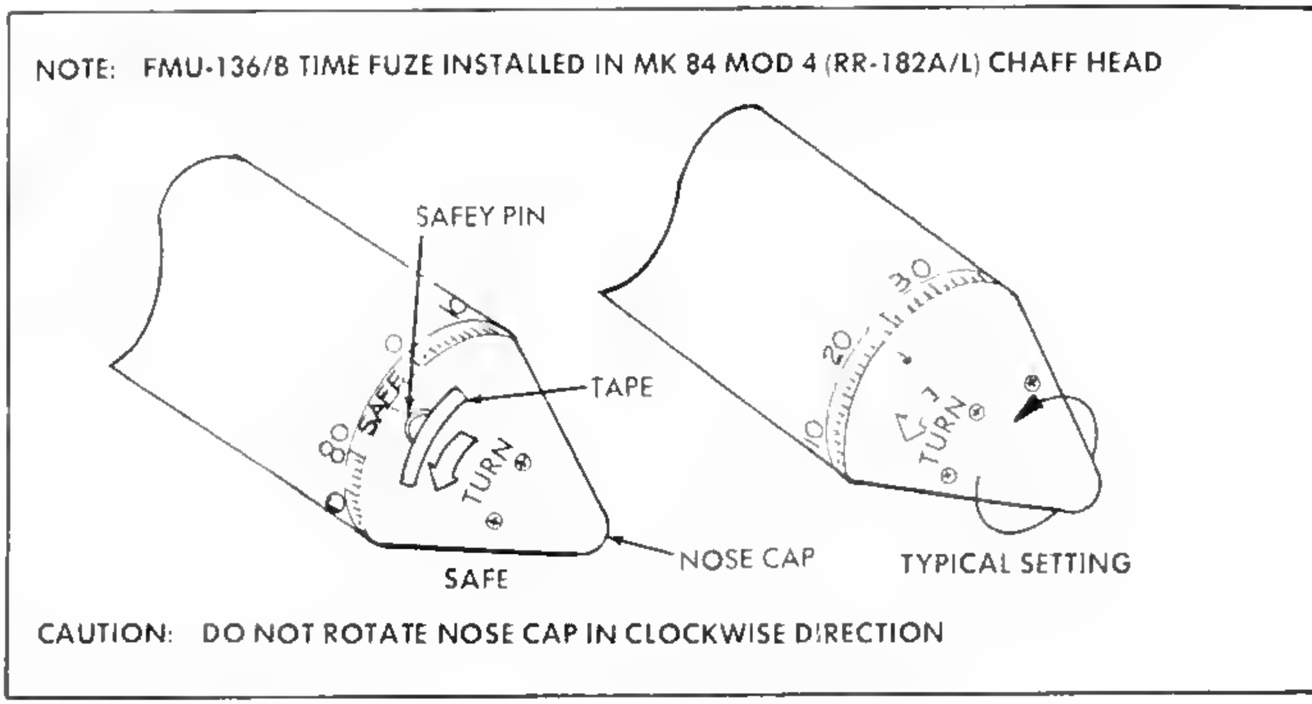


Figure 4-35. Airborne Rocket Fuzes (Sheet 2 of 2)

4.27.8 M423 Impact (PD). The M423 nose fuze is used ONLY with Mk 40/66 2.75-inch rocket motors on slow speed aircraft/helicopters. The fuze is sensitive to low angle impacts as low as 5° and will function on water targets. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's in order to arm. Air travel to arm is approximately 140 to 300 feet and time to arm is 0.63 to 0.82 second at 27g's.

WARNING

Because of the short arming time, M423 nose fuzes must not be used in rockets fired from high speed aircraft.

4.27.9 M427 Impact (PD). The M427 nose fuze is identical to the M423 fuze with exception of a longer arming distance of 800 to 1,250 feet that requires a time to arm of 1.09 to 1.34 seconds at 40g's. It was designed for use with high speed aircraft; however, it may be used on slow speed aircraft by using a greater target standoff distance.

4.27.10 Mk 188 Mod 0 Impact (PD). The Mk 188 Mod 0 nose fuze was designed to be used with 5.00-inch warheads against ground/water targets. The fuze will function reliably at low angle impacts. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's in order to arm. Air travel to arm is approximately 400 to 800 feet and time to arm is 0.7 to 0.9 second.

4.27.11 Mk 191 Impact (BD). The Mk 191 base fuze is permanently installed in the 5.00-inch Mk 24 Mod 0 GP warhead. The fuze has a .002- to .007-second functioning delay after impact and does not function reliably on impact with water. The fuze was designed for hard target penetration and must be used in combination with a hardened steel noseplug installed in the nose fuze cavity when used for that purpose. This fuze requires a sustained acceleration of 30g's in order to arm. Air travel to arm is approximately 400 to 800 feet and time to arm is approximately 0.8 to 1.0 second at 50g's.

4.27.12 Mk 193 Time. The Mk 193 time fuze is permanently installed in the 5.00-inch Mk 33 Mod 1 flare warhead. The fuze provides a preset fixed time interval that commences at launch. The flare candle will be ignited 13 to 17 seconds after launch. This fuze requires a sustained acceleration of 30g's in order to enable and arms at motor burnout. Air travel to arm is approximately 1,000 feet and time to arm is approximately 1.0 second.

4.27.13 M442 Time. The M442 time fuze is permanently installed in the M257 2.75-inch flare warhead. The fuze provides a preset fixed time interval that commences at rocket launch. The flare candle will ignite approximately 13.5 seconds after launch. The fuze requires a sustained acceleration of 16g's in order to enable and arms at motor burnout. Air travel to arm is approximately 1,800 feet (Mk 40 motor) or 2,137 feet (Mk 66 motor) and time to arm is approximately 1.0 second.

4.27.14 FMU-136/B Time Fuze. The FMU-136/B time fuze is permanently installed in the Mk 84 Mod 4 5.00-inch CHAFF warhead. The fuze provides a preflight selectable functioning time (3 to 80 seconds) in 0.5-second increments that commences approximately 0.2 second after launch. The fuze requires a sustained acceleration of 30g's to arm. Air travel to arm is approximately 400 to 600 feet and time to arm is 0.65 to 0.85 second at 60g's.

4.27.15 Model 113A. The Model 113A base fuze is permanently installed in the WDU-4A/A flechette warhead. Fuze functioning at motor burnout provides flechette expulsion. The fuze requires a sustained acceleration of 25g's in order to arm and fires when deceleration reaches approximately 11g's. Air travel to arm is approximately 550 to 1,400 feet with flechette expulsion occurring approximately 1.6 seconds after motor firing.

4.27.16 M429 Proximity. The M429 proximity nose fuze was designed to be used only with the 2.75-inch M229 HE-FRAG warhead/Mk 40 rocket motor combination on slow speed aircraft/helicopters operating against ground targets at low approach angles. The fuze has two modes of operation: airburst (primary) and impact (secondary) backup in the event of proximity failure. Target approach angles between 5° to 15° will provide a burst height between 2 to 12 feet (7-feet nominal over average ground). The fuze requires a sustained acceleration of 30g's in order to arm. Air travel to arm is approximately 500 to 1,100 feet and time to arm is 1.04 to 1.34 seconds at 27g's.

4.27.17 Mk 93 Mod 0/M414A1 Proximity. The Mk 93 Mod 0/M414A1 nose fuzes were designed to be used with 5.00-inch warheads against ground targets at low approach angles. This fuze, coupled with the Mk 32 AT/APERS warhead, is highly effective for flak suppression and antipersonnel missions. The fuze has two modes of operation: airburst (primary) and impact (secondary) backup in the event of proximity failure. The only difference between the two fuzes is the burst height range. The Mk 93 Mod 0 fuze provides a higher burst height (35 to 60 feet) that is required for the Mk 63 HE-FRAG warhead. The M414A1 provides a burst height of 15 to 40 feet. Burst height ranges for both fuzes are based on average ground and at target approach angles of 20° to 40°. This fuze requires a sustained acceleration of 30g's in order to enable and arms at motor burnout. Air travel to arm is approximately 1,000 feet and time to arm is approximately 1.0 second.

4.27.18 BBU-15/B Adapter Booster. The BBU-15/B adapter booster was designed to allow the installation of the Mk 352/FMU-90/B 2.75-inch impact nose fuzes in Mk 24/32/34/63 5.00-inch warheads.

4.27.19 Preflight Checks. With the exception of the FMU-136/B time fuze (Mk 84 Mod 4 CHAFF warhead/ RR-182/AL CHAFF countermeasures head), there are no preflight checks to be performed on rocket fuzes.

1. (FMU-136/B) functioning time — SET AS DESIRED.

4.28 MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

4.28.1 Introduction. The vertical distance required for the weapon to have sufficient time of fall to allow the fuze to arm is presented in Figure 4-36. These altitudes are based on impact occurring at the fuze arming time plus a late arm tolerance. Late arm times for the M904 fuze are presented in Figure 4-37, Fuze Characteristics. Minimum release altitudes for fragment avoidance are based on a probability of hit of less than or equal to 1 in 10,000,000 for the last bomb released in the stick. The minimum fragment and terrain avoidance altitudes are based on a straight path dive release with a 3g wings level pullup and a level release with a 2g level breakaway recovery.

OV-10A MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

WEAPON:		MK 81 MOD 1													
FIN ASSEMBLY:		CONICAL					MK 14 MOD 2								
MODE:							LOW DRAG					HIGH DRAG			
ARMING TIMES:		4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MINIMUM RELEASE ALTITUDES (FT-MSL)													
0	200	1000F	1000F	1233	1920	2756	1100F	1100F	1222	1809	2717	800F	800F	896	1312
	250	1000F	1000F	1230	1916	2748	1000F	1000F	1217	1890	2703	500F	521	867	1272
-10	200	1500F	1500F	1740	2551	3508	1500F	1500F	1722	2518	3451	1000F	1000F	1200	1644
	250	1400F	1400F	1863	2701	3684	1400F	1400F	1839	2659	3613	800F	830	1225	1662
-20	200	1700F	1700F	2232	3162	4236	1700F	1700F	2206	3116	4159	1200F	1200F	1488	1955
	250	1800F	1800F	2475	3462	4589	1800F	1800F	2441	3401	4491	900F	1125	1562	2027
-30	200	2000F	2000F	2693	3734	4917	1900F	1900F	2660	3675	4820	1400F	1400F	1751	2240
	250	2100F	2100F	3049	4174	5436	2100F	2100F	3004	4095	5311	1431T	1431T	1871	2361
-45	200	2400F	2400F	3296	4483	5807	2400F	2400F	3252	4406	5684	2001T	2001T	2087	2602
	250	2700F	2700F	3801	5105	6542	2700F	2700F	3740	5001	6380	2454T	2454T	2454T	2785

NOTES:
1. Data based on level release with 2g level breakaway and straight path dive release with 3g wings level pullup.
2. F - Indicates fragment avoidance minimum altitude.
3. T - Indicates terrain avoidance minimum altitude.

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BF 11105-R1
BF 11103-R2

Figure 4-36. Minimum Release Altitudes Required For Fuze Arm (Sheet 1 of 6)

OV-10A MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

WEAPON:		MK 82 MOD 2 (TP)													
FIN ASSEMBLY:		CONICAL					MK 15								
MODE:							LOW DRAG					HIGH DRAG			
ARMING TIMES:		4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MINIMUM RELEASE ALTITUDES (FT-MSL)													
0	200	1400F	1400F	1400F	1918	2753	1400F	1400F	1400F	1905	2728	800F	800F	996	1479
	250	900F	900F	1229	1914	2746	900F	900F	1221	1898	2716	700F	700F	950	1409
-10	200	2200F	2200F	2200F	2548	3504	2200F	2200F	2200F	2527	3467	1000F	1000F	1358	1888
	250	1900F	1900F	1900F	2692	3681	1300F	1300F	1846	2671	3634	1000F	1000F	1370	1873
-20	200	2200F	2200F	2230	3158	4230	2200F	2200F	2214	3129	4181	1200F	1200F	1701	2274
	250	2300F	2300F	2473	3459	4586	1600F	1621	2451	3419	4520	1300F	1300F	1768	2322
-30	200	2400F	2400F	2690	3730	4911	2400F	2400F	2660	3602	4848	1400F	1441	2018	2628
	250	2500F	2500F	3047	4171	5433	2500F	2500F	3017	4118	5347	1500F	1563	2134	2727
-45	200	2500F	2500F	3293	4478	5801	2400F	2400F	3265	4428	5720	2001T	2001T	2425	3081
	250	2600F	2633	3798	5103	6541	2500F	2613	3758	5032	6427	2454T	2454T	2603	3244

NOTES:
1. Data based on level release with 2g level breakaway and straight path dive release with 3g wings level pullup.
2. F - Indicates fragment avoidance minimum altitude.
3. T - Indicates terrain avoidance minimum altitude.

BF 11213-R2
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Figure 4-36. Minimum Release Altitudes Required For Fuze Arm (Sheet 2 of 6)

OV-10A MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

WEAPON: MK 83 MOD 5 (TP)

FIN ASSEMBLY:		CONICAL				
ARMING TIMES:		4.0	6.0	8.0	10.0	12.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MINIMUM RELEASE ALTITUDES (FT-MSL)				
0	200	1100F	1100F	1238	1932	2777
	250	1100F	1100F	1237	1929	2773
-10	200	1600F	1600F	1750	2569	3539
	250	1500F	1500F	1875	2725	3724
-20	200	1800F	1800F	2246	3187	4278
	250	1800F	1800F	2494	3495	4644
-30	200	2000F	2000F	2710	3766	4969
	250	2600F	2600F	3074	4217	5507
-45	200	2400F	2400F	3319	4524	5875
	250	2800F	2800F	3834	5163	6636

NOTES:
1. Data based on level release with 2g level breakaway and straight path dive release with 3g wings level pullup.
2. F - Indicates fragment avoidance minimum altitude.
3. T - Indicates terrain avoidance minimum altitude.

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Figure 4-36. Minimum Release Altitudes Required For Fuze Arm (Sheet 3 of 6)

OV-10D MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

WEAPON:		MK 81 MOD 1													
FIN ASSEMBLY:		CONICAL					MK 14 MOD 2								
MODE:							LOW DRAG					HIGH DRAG			
ARMING TIMES:		4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MINIMUM RELEASE ALTITUDES (FT-MSL)													
0	200	1100F	1100F	1233	1920	2756	1000F	1100F	1222	1809	2717	800F	800F	896	1312
	250	1000F	1000F	1230	1916	2748	1000F	1000F	1217	1800	2703	400F	521	867	1272
-10	200	1500F	1500F	1740	2551	3508	1500F	1500F	1722	2518	3451	1000F	1000F	1200	1644
	250	1400F	1400F	1863	2701	3684	1300F	1300F	1839	2659	3613	700F	830	1225	1662
-20	200	1700F	1700F	2232	3162	4236	1700F	1700F	2206	3116	4159	1200F	1200F	1488	1955
	250	1700F	1700F	2475	3462	4589	1700F	1700F	2441	3401	4491	900F	1125	1562	2027
-30	200	2000F	2000F	2693	3734	4917	1900F	1900F	2660	3675	4820	1300F	1300F	1751	2240
	250	2100F	2100F	3049	4174	5436	2100F	2100F	3004	4005	5311	1462T	1462T	1871	2361
-45	200	2400F	2400F	3296	4483	5807	2400F	2400F	3252	4406	5684	2037T	2037T	2087	2602
	250	2600F	2634	3801	5105	6542	2600F	2604	3740	5001	6380	2529T	2529T	2529T	2785

NOTES:
1. Data based on level release with 2g level breakaway and straight path dive release with 3g wings level pullup.
2. F - Indicates fragment avoidance minimum altitude.
3. T - Indicates terrain avoidance minimum altitude.

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BF 11105-R1
BF 11103-R2

Figure 4-36. Minimum Release Altitudes Required For Fuze Arm (Sheet 4 of 6)

OV-10D MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

WEAPON:		MK 82 MOD 2 (TP)													
FIN ASSEMBLY:		CONICAL					MK 15								
MODE:							LOW DRAG					HIGH DRAG			
ARMING TIMES:		4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MINIMUM RELEASE ALTITUDES (FT-MSL)													
0	200	1400F	1400F	1400F	1918	2753	1400F	1400F	1400F	1905	2728	1100F	1100F	1100F	1479
	250	900F	900F	1229	1914	2746	900F	900F	1221	1898	2716	700F	700F	950	1409
-10	200	1900F	1300F	1900F	2548	3504	2000F	2000F	2000F	2527	3467	1500F	1500F	1500F	1888
	250	1200F	1200F	1861	2699	3681	1200F	1200F	1846	2671	3634	900F	917	1370	1879
-20	200	2100F	2100F	2230	3158	4230	2100F	2100F	2214	3129	4181	1600F	1600F	1701	2274
	250	1600F	1632	2473	3459	4586	1600F	1621	2451	3419	4520	1200F	1252	1768	2322
-30	200	2300F	2300F	2690	3730	4911	2300F	2300F	2669	3692	4848	1700F	1700F	2018	2628
	250	2000F	2066	3047	4171	5433	1900F	2051	3017	4118	5347	1500F	1563	2134	2727
-45	200	2400F	2400F	3293	4478	5801	2400F	2400F	3265	4128	5720	2037T	2037T	2425	3081
	250	2529T	2633	3738	5103	6541	2529T	2613	3758	5032	6427	2529T	2529T	2603	3244

NOTES:
1. Data based on level release with 2g level breakaway and straight path dive release with 3g wings level pullup.
2. F - Indicates fragment avoidance minimum altitude.
3. T - Indicates terrain avoidance minimum altitude.

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BF 11216-R6

Figure 4-36. Minimum Release Altitudes Required For Fuze Arm (Sheet 5 of 6)

OV-10D MINIMUM RELEASE ALTITUDES REQUIRED FOR FUZE TO ARM

WEAPON: MK 83 MOD 5 (TP)

FIN ASSEMBLY: CONICAL

RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	ARMING TIMES: 4.0	6.0	8.0	10.0	12.0
		MINIMUM RELEASE ALTITUDES (FT-MSL)				
0	200	1100F	1100F	1238	1932	2777
	250	1100F	1100F	1237	1929	2773
-10	200	1600F	1600F	1750	2569	3539
	250	1400F	1400F	1875	2725	3724
-20	200	1800F	1800F	2246	3187	4278
	250	1800F	1800F	2494	3495	4644
-30	200	2000F	2000F	2710	3766	4969
	250	2200F	2200F	3074	4217	5507
-45	200	2800F	2800F	3319	4524	5875
	250	2900F	2900F	3834	5163	6636

NOTES:
1. Data based on level release with 2g level breakaway and straight path dive release with 3g wings level pullup.
2. F - Indicates fragment avoidance minimum altitude
3. T Indicates terrain avoidance minimum altitude.

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Figure 4-36. Minimum Release Altitudes Required For Fuze Arm (Sheet 6 of 6)

FUZE CHARACTERISTICS

FUZE	ARMING TIMES (SEC)	EARLY ARM TIMES (SEC)	LATE ARM TIMES (SEC)	PROBABILITY OF EARLY BURST (PEB)
M904 SERIES	2.0*	1.8*	2.4*	0.00001
	4.0*	3.6*	4.4*	
	6.0	5.4	6.6	
	8.0	7.2	8.8	
	10.0	9.0	11.0	
	12.0	10.8	13.2	
	14.0	12.6	15.4	
	16.0	14.4	17.6	
	18.0	16.2	19.8	

* THESE ARMING TIMES ARE ONLY AUTHORIZED FOR HIGH DRAG DELIVERIES.

Figure 4-37. Fuze Characteristics

4.29 EARLY BURST MANEUVERS

4.29.1 Introduction. Early burst data for fuze arming time/stick length combinations are determined by performing the following maneuvers and are based on an 11,000-pound aircraft weight for the OV-10A and a 13,000-pound aircraft weight for the OV-10D and 100-percent military power at the end of the response delay. Also, higher g's and/or less g-buildup times than those stated in the maneuver descriptions result in added safety.

4.29.2 Level Release With a 2G Level Breakaway. A constant velocity flight is maintained during weapon release and for a 1.5-second pilot/aircraft response delay after the last weapon is released. After the response delay, the load factor is increased linearly to 2.0g's in 1.5 seconds and the aircraft is rolled as a function of the load factor in order to maintain a level flightpath turn. This load factor (or the maximum attainable within the angle-of-attack limits) is maintained until a 90° heading change is achieved.

4.29.3 Dive Release With a 3G Level Breakaway. A straight-path flight is maintained during weapon release and for a 1.5-second pilot/aircraft response delay after the last weapon is released. At the end of the response delay, the load factor is increased linearly to 3.0g's in 1.5 seconds and the aircraft is rolled as a function of the load factor in order to maintain a level flightpath turn. This load factor (or the maximum attainable within the angle-of-attack limits) is maintained until a 90° heading change is achieved.

4.29.4 Fuze Arming Times. The proper selection of fuze arming times is one of the most important aspects of weapon delivery from the standpoint of safety and reliability. Choosing the proper fuze arming time will ensure that: (1) the delivered weapons will have sufficient time to arm properly before impact, and (2) in the event of weapon detonation at arming, the probability of damage to the delivery aircraft will be minimized. A detonation either at or shortly after arming is known as an *early burst*. The resulting damage to the aircraft can range from minor fragment hits to catastrophic loss of aircraft and aircrew. Early bursts can result from bomb-to-bomb collision, bomb-to-aircraft collision, or fuze malfunction. Figure 4-39 presents authorized fuze arming times versus maximum stick lengths which ensure that, in the event of an early burst, the probability of fragment hit is within acceptable limits. To minimize the possibility of aircraft damage, refer to Bomb Fuzing text and select arming times in accordance with the procedures given in Instructions for Use of Figure 4-39.

Note

Arming times less than those listed are unauthorized; arming times greater than those listed are authorized for stick lengths up to and including 4.0 seconds, providing the weapon's time of fall exceeds the arming time.

Refer to Figure 4-36, Minimum Release Altitudes Required for Fuze to Arm charts to obtain the altitude necessary for proper time of fall. Data defining authorized fuze arming times and probability of hit are based on early burst occurring at the fuze arming time considering the early arm tolerance of the M904 fuze. The early arm tolerances for the M904 fuze are given in Figure 4-37.

WARNING

No data are provided for airspeeds less than 200 KTAS; therefore, releases at less than 200 KTAS are prohibited. For airspeeds greater than 250 KTAS, use the 250 KTAS stick length parameters. For airspeeds between those provided, use the stick length for the slower of the two contiguous airspeeds. Do not interpolate.

Note

All stick lengths consider a single weapon detonation of the worst case bomb at the fuze arming time. A 0.0-second stick length indicates a single release pulse. Stick lengths greater than 4.0 seconds have not been evaluated. For those cases marked UA, the fuze arming time is unauthorized; for those marked DUD, the fuze arming time exceeds the weapon's time of fall.

4.29.5 Safety Criteria for Authorized Fuze Arming Times. A fuze arming time is authorized if the following safety criteria are met:

1. For each weapon released in a stick, the probability of fragment hit on the delivery aircraft in the event of early burst (PH/EB) at fuze arming time will not exceed 1 in 10 (0.10).

2. The overall probability of fragment hit (P_H) per weapon release will not exceed 1 in 10,000 (0.0001).

The overall probability of fragment hit, P_H, is defined as the product of $P_{H/EB}$ and P_{EB}. $P_{H/EB}$ is the probability of at least one fragment hit on the delivery aircraft in the event of an early burst at fuze arming. P_{EB} is the probability of occurrence of an early burst and is derived from range testing and updated by ordnance expenditure and incident reports. Early burst probabilities and arming times for the M904 fuze are given in Figure 4-37.

4.29.6 Instructions for Use of Figure 4-39. The data in Figure 4-39 for the M904 fuze are presented as maximum stick lengths in seconds versus fuze arming times for specified aircraft release and recovery maneuvers and are determined by performing the following steps:

1. Obtain authorized arming times and maximum stick length combinations from Figure 4-39 by determining the following parameters:

   (a) Type of release (level or straight path dive)

   (b) Type of recovery (breakaway)

   (c) Bomb/fin/fuze/combinations

   (d) Number of weapons delivered per pass

   (e) Release conditions (angle, airspeed, and altitude FT-MSL).

   (f) Release interval.

2. Record from Figure 4-39 for the selected weapon at the intended release conditions, the maximum permissible stick lengths for the available arming times.

3. Compute the total stick length (TSL) in seconds.

$$TSL = (N - 1) \times (I)$$

where:

TSL is the time in seconds between first and last weapons released. N is the total number of release pulses. I is the release interval in seconds.

4. If the stick lengths recorded in step 2 are equal to or greater than total stick length (TSL) from step 3, then the corresponding arming time(s) for those stick lengths are authorized. If the recorded stick lengths are less than TSL, then the corresponding arming times are unauthorized.

5. Be certain that the intended maneuver is compatible with release/carriage speed restrictions.

4.29.6.1 Sample Problem. Determine authorized fuze arming times for the following delivery:

Type Release: OV-10D Dive
Type Recovery: 3.0g-Level Breakaway
Fuze: M904
Weapon: 4 Mk 82 Mod 2 (TP) Bombs
Fin Assembly: Conical
Release Altitude: 7,000 ft-MSL
Release Angle: -30°
Release Velocity: 250 KTAS
Release Interval: 250 ms

1. Select the data as shown from Figure 4-38 under title: OV-10D Dive Release With a 3g Level Breakaway Recovery 5,001 to 10,000 Ft-MSL Release Altitude M904 Fuze.

2. Record the permissible stick length versus arming times for the given conditions.

ARMING TIMES (Seconds)	MAXIMUM STICK LENGTHS (SECONDS)
8.0	0.8
10.0*	4.0

*M904 Arming Times greater than 10.0 seconds are authorized for stick lengths up to and including 4.0 seconds.

3. Total Stick Length (TSL) = (4-1) X (0.250).

$$TSL = 0.75 \text{ second.}$$

4. Comparing the stick length computed in step 3 (0.75 second) to the values obtained from Figure 4-38, the values for the 8.0- and 10.0-second arming times are greater than 0.75; thus, 8.0 and 10.0 seconds are authorized arming times for the considered delivery parameters.

5. If the resulting arming times are tactically *too high*, then:

OV-1DD DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY
5,001 TO 10,000 FT-MSL RELEASE ALTITUDE
M904 FUZE

WEAPON		MK 81 MOD 1					MK 82 MOD 2 (TP)							MK 83 MOD 5 (TP)	
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2				CONICAL		MK 15					CONICAL	
MODE:			LOW DRAG		HIGH DRAG				LOW DRAG		HIGH DRAG				
ARMING TIMES:		8.0	8.0	10.0	4.0	6.0	8.0	10.0	8.0	10.0	6.0	8.0		8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)													
-10	200	1.2	1.2	4.0	UA	3.8	0.8	4.0	0.8	4.0	UA	1.2		0.6	4.0
	250	1.4	1.6	4.0	0.4	4.0	1.0	4.0	1.0	4.0	1.4	4.0		0.8	4.0
-20	200	1.2	1.2	4.0	UA	3.2	1.0	4.0	1.0	4.0	UA	1.6		0.6	3.8
	250	1.4	1.4	4.0	0.8	4.0	1.0	4.0	1.0	4.0	1.8	4.0		0.6	3.8
-30	200	1.2	1.0	4.0	UA	2.6	0.8	4.0	0.8	4.0	UA	1.8		0.6	3.6
	250	1.2	1.2	4.0	1.2	4.0	0.8	4.0	0.8	4.0	2.0	4.0		0.6	3.6
-45	200	0.8	0.8	3.8	UA	2.2	0.6	3.4	0.6	3.2	0.0	2.0		0.4	3.0
	250	1.0	1.0	3.8	1.4	4.0	0.6	3.4	0.6	3.2	2.6	4.0		0.4	3.0

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-38. OV-10D Dive Release With a 3g Level Breakaway Recovery — Sample Problem

(a) Reduce the number of weapons released or the release interval time or both, or

(b) Investigate Figure 4-39 for other possible specific release conditions that permit the stick length computed in Step 3 for the arming time desired, or

(c) Investigate the possibility of employing another type of maneuver for which data are available, or

(d) Refer to Figure 4-41 and related text defining the probability of fragment hit in the event of early burst. This chart may be used only if the officer-in-tactical-command (OTC) follows the necessary procedures in selecting arming time(s) shorter than those authorized.

OV-10A LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY
M904 FUZE

WEAPON:		MK 81 MOD 1			MK 82 MOD 2 (TP)				MK 83 MOD 5 (TP)
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2		CONICAL	MK 15			CONICAL
MODE:			LOW DRAG	HIGH DRAG		LOW DRAG	HIGH DRAG		
ARMING TIMES:		8.0	8.0	4.0	8.0	8.0	6.0	8.0	8.0
RELEASE CONDITIONS:									
ALTITUDE (FT-MSL)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)							
MIN TO 5,000	200	1.2	1.2	UA	0.8	0.8	UA	4.0	0.4
	250	1.4	1.6	4.0	0.8	0.8	4.0	4.0	0.4
5,001 TO 10,000	200	0.6	0.8	UA	0.2	0.2	UA	1.0	0.0
	250	0.6	0.8	UA	0.2	0.2	UA	4.0	0.0

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-39. Minimum Fuze Arming Times/Maximum Stick Lengths (Sheet 1 of 6)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY
MINIMUM TO 5,000 FT-MSL RELEASE ALTITUDE
M904 FUZE

WEAPON:		MK 81 MOD 1				MK 82 MOD 2 (TP)							MK 83 MOD 5 (TP)	
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2			CONICAL	MK 15						CONICAL	
MODE:			LOW DRAG	HIGH DRAG			LOW DRAG		HIGH DRAG					
ARMING TIMES:		8.0	8.0	4.0	6 0	8.0	8.0	10.0	6.0	8.0			8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)												
-10	200	1.6	1.8	UA	4.0	1.4	1.4	4.0	UA	4.0			1.2	4.0
	250	1.6	1.8	4.0	4.0	1.4	1.4	4.0	4.0	4.0			1.2	4.0
-20	200	1.6	1.6	UA	4.0	1.2	1.2	4.0	UA	3.2			1.0	4.0
	250	1.6	1.8	4 0	4.0	1.2	1.2	4.0	4.0	4.0			1.0	4.0
-30	200	1.4	1.4	UA	4.0	1.0	1.0	4.0	UA	2.8			0.8	4.0
	250	1.4	1.6	3.6	4.0	1.0	1.0	4.0	3.6	4.0			0.8	4.0
-45	200	1.2	1.0	0.2	3.2	0.8	0.8	3.8	0.4	2.8			0.6	3.8
	250	1.2	1.2	3.4	4.0	0.8	0.8	DUD	3.8	4 0			0.6	DUD

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-39. Minimum Fuze Arming Times/Maximum Stick Lengths (Sheet 2 of 6)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY 5,001 TO 10,000 FT-MSL RELEASE ALTITUDE M904 FUZE

WEAPON:		MK 81 MOD 1				MK 82 MOD 2 (TP)						MK 83 MOD 5 (TP)	
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2			CONICAL		MK 15				CONICAL	
MODE:			LOW DRAG	HIGH DRAG				LOW DRAG		HIGH DRAG			
ARMING TIMES:		8.0	8.0	4.0	6.0	8.0	10.0	8.0	10.0	6.0	8.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)											
-10	200	1.4	1.2	UA	3.6	1.0	4.0	1.0	4.0	UA	1.2	0.8	4.0
	250	1.4	1.2	UA	4.0	1.0	4.0	1.0	4.0	0.0	4.0	0.8	4.0
-20	200	1.2	1.2	UA	3.2	0.8	4.0	0.8	4.0	UA	1.4	0.8	4.0
	250	1.2	1.2	0.2	4.0	0.8	4.0	0.8	4.0	1.2	4.0	0.8	4.0
-30	200	1.2	1.2	UA	2.4	0.8	4.0	0.8	4.0	UA	1.6	0.6	3.6
	250	1.2	1.2	0.8	4.0	0.8	4.0	0.8	4.0	1.4	4.0	0.6	3.6
-45	200	0.8	0.8	UA	2.0	0.6	3.6	0.6	3.4	UA	1.6	0.4	3.2
	250	1.0	1.0	1.2	4.0	0.6	3.6	0.6	3.4	2.2	4.0	0.4	3.2

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-39. Minimum Fuze Arming Times/Maximum Stick Lengths (Sheet 3 of 6)

OV-10D LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY
M904 FUZE

WEAPON:		MK 81 MOD I			MK 82 MOD 2 (TP)				MK 83 MOD 5 (TP)
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2		CONICAL	MK 15			CONICAL
MODE:			LOW DRAG	HIGH DRAG		LOW DRAG	HIGH DRAG		
ARMING TIMES:		8.0	8.0	4.0	8.0	8.0	6.0	8.0	8.0
RELEASE CONDITIONS: ALTITUDE (FT-MSL)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)							
MIN TO 5,000	200	1.2	1.2	UA	0.8	0.8	UA	4.0	0.4
	250	1.8	2.0	4.0	1.0	1.0	4.0	4.0	0.4
5,001 TO 10,000	200	0.8	0.8	UA	0.4	0.4	UA	1.2	UA
	250	1.0	1.0	UA	0.4	0.4	UA	4.0	UA

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R2IA
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-39. Minimum Fuze Arming Times/Maximum Stick Lengths (Sheet 4 of 6)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY MINIMUM TO 5,000 FT-MSL RELEASE ALTITUDE M904 FUZE

WEAPON:		MK 81 MOD 1				MK 82 MOD 2 (TP)						MK 83 MOD 5 (TP)	
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2			CONICAL		MK 15				CONICAL	
MODE:			LOW DRAG	HIGH DRAG				LOW DRAG		HIGH DRAG			
ARMING TIMES:		8.0	8.0	4.0	6.0	8.0	10.0	8.0	10.0	6.0	8.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)											
-10	200	1.8	1.8	UA	4.0	1.4	4.0	1.4	4.0	UA	4.0	1.0	4.0
	250	2.0	2.0	4.0	4.0	1.4	4.0	1.4	4.0	4.0	4.0	1.0	4.0
-20	200	1.6	1.6	UA	4.0	1.4	4.0	1.2	4.0	UA	3.6	1.0	4.0
	250	1.8	1.8	4.0	4.0	1.4	4.0	1.4	4.0	4.0	4.0	1.0	4.0
-30	200	1.4	1.4	UA	4.0	1.2	4.0	1.0	4.0	0.2	3.0	0.8	4.0
	250	1.6	1.6	3.6	4.0	1.2	4.0	1.2	4.0	3.6	4.0	0.8	4.0
-45	200	1.2	1.2	0.4	3.4	0.8	3.8	0.8	3.6	0.6	3.0	0.6	3.6
	250	1.4	1.2	3.6	4.0	1.0	DUD	1.0	DUD	4.0	4.0	0.6	DUD

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-39. Minimum Fuze Arming Times/Maximum Stick Lengths (Sheet 5 of 6)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY
5,001 TO 10,000 FT-MSL RELEASE ALTITUDE
M904 FUZE

WEAPON:		MK 81 MOD 1					MK 82 MOD 2 (TP)						MK 83 MOD 5 (TP)	
FIN ASSEMBLY:		CONICAL	MK 14 MOD 2				CONICAL		MK 15				CONICAL	
MODE:			LOW DRAG		HIGH DRAG				LOW DRAG		HIGH DRAG			
ARMING TIMES:		8.0	8.0	10.0	4.0	6.0	8.0	10.0	8.0	10.0	6.0	8.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	VELOCITY (KTAS)	MAXIMUM STICK LENGTH (SECONDS)												
-10	200	1.2	1.2	4.0	UA	3.8	0.8	4.0	0.8	4.0	UA	1.2	0.6	4.0
	250	1.4	1.6	4.0	0.4	4.0	1.0	4.0	1.0	4.0	1.4	4.0	0.8	4.0
-20	200	1.2	1.2	4.0	UA	3.2	1.0	4.0	1.0	4.0	UA	1.6	0.6	3.8
	250	1.4	1.4	4.0	0.8	4.0	1.0	4.0	1.0	4.0	1.8	4.0	0.6	3.8
-30	200	1.2	1.0	4.0	UA	2.6	0.8	4.0	0.8	4.0	UA	1.8	0.6	3.6
	250	1.2	1.2	4.0	1.2	4.0	0.8	4.0	0.8	4.0	2.0	4.0	0.6	3.6
-45	200	0.8	0.8	3.8	UA	2.2	0.6	3.4	0.6	3.2	0.0	2.0	0.4	3.0
	250	1.0	1.0	3.8	1.4	4.0	0.6	3.4	0.6	3.2	2.6	4.0	0.4	3.0

NOTES: 1. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2
BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-39. Minimum Fuze Arming Times/Maximum Stick Lengths (Sheet 6 of 6)

4.29.7 Probability of Fragment Hit in the Event of Early Burst. The probability of the delivery aircraft being hit by at least one fragment in the event of early burst at arming ($P_{H/EB}$) is given in Figure 4-41. The purpose of these charts is to provide increased tactical advantage by using shorter fuze arming times. The OTC may approve deviations from the minimum authorized arming times prescribed in Figure 4-39 when the tactical advantage realized by using shorter arming times justifies the resulting added risk. Deviations should be approved only when the authorized arming times will substantially limit or degrade mission effectiveness. The very low probability of early burst of the M904 fuze may permit use of shorter arming times under certain tactical situations without increasing the overall risk above that warranted by the mission. It must be recognized that an early burst at shorter arming times will not only increase the probability of a fragment hit but will also increase the severity of damage in the event of a hit.

WARNING

The minimum authorized arming times in Figure 4-39 are computed on the basis that the probability of a fragment hit on the delivery aircraft in the event of an early burst ($P_{H/EB}$) shall not exceed 1 in 10 (0.10) and the overall probability of a fragment hit per each bomb dropped (P_H) shall not exceed 1 in 10,000 (0.0001). When deviations to these safety criteria are necessary, latitude may be exercised in accepting higher values of $P_{H/EB}$, but the established limit of P_H of 1 in 10,000 shall not be exceeded. P_H is the product of $P_{H/EB}$ and P_{EB}. P_{EB} is the probability of early burst given in Figure 4-37.

Note

In Figure 4-41, arming times less than those listed have a probability of hit given early burst ($P_{H/EB}$) of 1.0 and arming times greater than those listed have no probability (NP) of hit given early burst. In Figure 4-41, NP is defined as a probability of hit given early burst of less than or equal to 5 in 10,000. $P_{H/EB}$ values presented in Figure 4-41 are for a range of airspeeds and cannot be directly compared to every stick length value presented in Figure 4-39. The $P_{H/EB}$ values for the range of airspeeds are provided based on the airspeed resulting in the highest $P_{H/EB}$ for the given release condition. These values are applicable to any airspeed within the given range.

4.29.8 Instructions for Use of Figure 4-41. In the event that the OTC determines that it is crucial to release at the lowest possible altitude, an arming time less than the minimum authorized arming time obtained from Figure 4-39 will be needed. The risk in using this shorter arming time would be obtained from Figure 4-41 in the following manner:

1. Locate the entry point to the figure by identifying:

   (a) Release/recovery maneuver.

   (b) Release airspeed, angle, and altitude.

   (c) Weapon configuration.

   (d) Arming time for which an estimation of hazard is desired.

   (e) Stick length (seconds) — round up the total stick length computed in Figure 4-39 to the nearest second.

2. Record necessary values of $P_{H/EB}$.

3. Obtain P_{EB} (probability of early burst) for the M904 fuze from Figure 4-37, Fuze Characteristics.

4. Compute the overall probability of fragment hit (P_H) by multiplying $P_{H/EB}$ (step 2) and P_{EB} (step 3). Compare P_H to the constraint defined in the WARNING in paragraph 4.29.7. Note that the low early burst probability of the M904 allows the constraint ($P_H \leq 0.0001$) to be satisfied even when $P_{H/EB}$ is 1.0.

4.29.8.1 Sample Problem. Determined P_H using a shorter arming time than was authorized in the previous sample problem.

Type Release: OV-10D Dive
Type Recovery: 3.0g Level Breakaway
Weapon: 4-Mk 82 Mod 2 (TP) Bombs
Fin Assembly: Conical
Release Altitude: 7,000 Feet-MSL
Release Angle: -30°
Release Velocity: 250 KTAS
Arming Time: 6.0 Seconds
Stick Length: 1.0 Second (0.75 second rounded up to the nearest second).
Fuze: M904

1. Select $P_{H/EB}$ as shown in Figure 4-40 under title: OV-10D Dive Release with a 3g Level Breakaway Recovery 5,001 to 10,000 Ft-MSL Release Altitude.

2. $P_{H/EB}$ = 0.992.

3. P_{EB} for the M904 fuze = 0.00001.

4. Compute the overall probability of hit (P_H).

$P_H = P_{H/EB} \text{ X } P_{EB}$

$P_H = 0.992 \text{ X } 0.00001$

$P_H = 0.00000992$

5. Since the computed P_H satisfies the constraint of $P_H \leq 0.0001$ in the WARNING, the 6.0-second arming time is permissible. However, if an early burst does occur at 6.0 seconds, the aircraft is sufficiently close to the detonation point that the probability of fragment hit ($P_{H/EB}$) is 0.992 (99.2 percent). At this point the OTC must decide if the mission requirements are worth the risk involved in using a 6.0-second arming time.

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY
5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON		MK 82 MOD 2 (TP)													
FIN ASSEMBLY:		CONICAL				MK 15									
MODE						LOW DRAG				HIGH DRAG					
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0	
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)													
-10	0.0	0.852	0.010	NP	NP	0.854	0.012	NP	NP	1.000	0.533	0.017	NP	NP	
	1.0	0.981	0.103	0.001	NP	0.981	0.104	0.001	NP	1.000	0.783	0.070	0.005	NP	
	2.0	0.984	0.292	0.006	NP	0.985	0.293	0.006	NP	1.000	0.853	0.150	0.010	NP	
	3.0	0.984	0.424	0.014	NP	0.985	0.430	0.015	NP	1.000	0.860	0.206	0.010	0.003	
	4.0	0.984	0.470	0.046	0.002	0.985	0.476	0.046	0.002	1.000	0.872	0.231	0.012	0.007	
-20	0.0	0.814	0.008	NP	NP	0.809	0.009	NP	NP	1.000	0.426	0.011	NP	NP	
	1.0	0.982	0.090	NP	NP	0.983	0.095	NP	NP	1.000	0.773	0.044	NP	NP	
	2.0	0.990	0.331	0.004	NP	0.991	0.343	0.004	NP	1.000	0.909	0.136	0.006	NP	
	3.0	0.990	0.461	0.018	NP	0.991	0.490	0.017	NP	1.000	0.927	0.250	0.013	NP	
	4.0	0.990	0.514	0.062	0.001	0.991	0.520	0.062	0.001	1.000	0.945	0.311	0.016	0.004	
-30	0.0	0.824	0.010	NP	NP	0.828	0.011	NP	NP	0.994	0.321	0.005	NP	NP	
	1.0	0.992	0.116	NP	NP	0.992	0.122	NP	NP	1.000	0.763	0.036	NP	NP	
	2.0	0.995	0.382	0.003	NP	0.997	0.405	0.003	NP	1.000	0.963	0.122	0.003	NP	
	3.0	0.995	0.552	0.021	NP	0.997	0.560	0.023	NP	1.000	0.973	0.296	0.016	NP	
	4.0	0.995	0.612	0.080	0.001	0.997	0.623	0.087	0.001	1.000	0.987	0.437	0.026	0.003	
-45	0.0	0.886	0.012	NP	NP	0.882	0.012	NP	NP	0.702	0.086	0.003	NP	NP	
	1.0	0.999	0.192	NP	NP	0.999	0.202	NP	NP	1.000	0.560	0.016	NP	NP	
	2.0	0.999	0.531	0.005	NP	0.999	0.558	0.006	NP	1.000	0.973	0.094	0.002	NP	
	3.0	0.999	0.753	0.066	NP	0.999	0.771	0.065	NP	1.000	1.000	0.417	0.013	NP	
	4.0	0.999	0.779	0.134	0.002	0.999	0.799	0.169	0.002	1.000	1.000	0.722	0.050	0.001	

NOTES. 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions

BF 11213-R2
BF 11217-R1
BF 11216-R6

Figure 4-40. OV-10D Dive Release With a 3g Level Breakway Recovery — Sample Problem

OV-10A LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY

WEAPON:		MK 81 MOD 1												
FIN ASSEMBLY:		CONICAL				MK 14 MOD 2								
MODE:						LOW DRAG				HIGH DRAG				
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0
RELEASE CONDITIONS: ALTITUDE (FT-MSL)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)												
MIN TO 5,000	0.0	0.828	0.015	NP	NP	0.817	0.010	NP	NP	0.410	0.025	0.002	NP	NP
	1.0	0.958	0.066	NP	NP	0.947	0.069	NP	NP	0.445	0.040	0.002	NP	NP
	2.0	0.958	0 138	0.001	NP	0.952	0.142	0.001	NP	0.445	0.040	0.003	NP	NP
	3.0	0.960	0.211	0.003	NP	0.958	0.198	0.004	NP	0.445	0.041	0.003	NP	NP
	4.0	0.960	0.265	0.007	NP	0.958	0.244	0.006	NP	0.445	0.041	0.003	NP	NP
5,001 TO 10,000	0.0	0.922	0.013	0.001	NP	0.912	0.016	0.002	NP	0.708	0.069	0.008	NP	NP
	1.0	0.978	0.124	0.001	NP	0.980	0.109	0.002	NP	0.715	0.085	0.015	NP	NP
	2.0	0.978	0.271	0.003	NP	0.980	0.272	0.003	NP	0.715	0.085	0.019	0.001	NP
	3.0	0.978	0.351	0.009	NP	0.980	0.350	0.019	NP	0.715	0.085	0.019	0.001	NP
	4.0	0.978	0.391	0.020	0.001	0.980	0.387	0.019	0.001	0.715	0.085	0.019	0.001	0.001

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 1 of 16)

OV-10A LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY

WEAPON:		MK 82 MOD 2 (TP)											
FIN ASSEMBLY:		CONICAL				MK 15							
MODE:						LOW DRAG				HIGH DRAG			
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0
RELEASE CONDITIONS ALTITUDE (FT-MSL)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
MIN	0.0	0.879	0.024	NP	NP	0.862	0.023	NP	NP	0.469	0.009	NP	NP
TO	1.0	0.961	0.121	NP	NP	0.956	0.114	NP	NP	0.595	0.032	NP	NP
5,000	2.0	0.965	0.251	NP	NP	0.962	0.234	NP	NP	0.643	0.050	NP	NP
	3.0	0.967	0.313	0.008	NP	0.967	0.297	0.007	NP	0.670	0.057	NP	NP
	4.0	0.967	0.343	0.015	NP	0.967	0.345	0.014	NP	0.670	0.058	NP	NP
5,001	0.0	0.930	0.071	0.002	NP	0.927	0.073	0.002	NP	0.647	0.041	0.007	NP
TO	1.0	0.982	0.212	0.007	NP	0.976	0.213	0.006	NP	0.759	0.092	0.007	NP
10,000	2.0	0.982	0.350	0.018	NP	0.979	0.345	0.016	NP	0.803	0.134	0.007	0.004
	3.0	0.982	0.410	0.019	0.004	0.981	0.401	0.018	0.003	0.831	0.155	0.007	0.007
	4.0	0.982	0.427	0.041	0.009	0.981	0.420	0.037	0.007	0.831	0.162	0.008	0.012

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11213-R2
BF 11217-R1
BF 11216-R6

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 2 of 16)

OV-10A LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY

WEAPON: MK 83 MOD 5 (TP)

FIN ASSEMBLY: CONICAL
MODE:

ARMING TIMES:		6.0	8.0	10.0	12.0
RELEASE CONDITIONS: ALTITUDE (FT-MSL)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)			
MIN	0.0	0.981	0.049	NP	NP
TO	1.0	0.993	0.173	0.001	NP
5,000	2.0	1.000	0.330	0.007	NP
	3.0	1.000	0.497	0.020	NP
	4.0	1.000	0.546	0.032	NP
5,001	0.0	1.000	0.097	0.005	NP
TO	1.0	1.000	0.274	0.008	NP
10,000	2.0	1.000	0.468	0.017	NP
	3.0	1.000	0.592	0.043	0.005
	4.0	1.000	0.638	0.069	0.008

NOTES:
1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11307-R1

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 3 of 16)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY MINIMUM TO 5,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 81 MOD 1									MK 82 MOD 2 (TP)		
FIN ASSEMBLY:		CONICAL			MK 14 MOD 2						CONICAL		
MODE:					LOW DRAG			HIGH DRAG					
ARMING TIMES:		6.0	8.0	10.0	6.0	8.0	10.0	4.0	6.0	8.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
-10	0.0	0.628	0.001	NP	0.626	0.001	NP	0.331	0.021	0.001	0.704	NP	NP
	1.0	0.961	0.024	NP	0.958	0.023	NP	0.404	0.033	0.001	0.968	0.045	NP
	2.0	0.967	0.123	NP	0.969	0.111	NP	0.512	0.037	0.003	0.974	0.211	NP
	3.0	0.967	0.220	0.002	0.969	0.265	0.002	0.512	0.041	0.005	0.974	0.359	0.002
	4.0	0.967	0.306	0.007	0.969	0.307	0.010	0.512	0.050	0.005	0.974	0.402	0.016
-20	0.0	0.646	0.002	NP	0.631	0.002	NP	0.287	0.017	NP	0.720	NP	NP
	1.0	0.972	0.028	NP	0.972	0.030	NP	0.415	0.032	0.001	0.977	0.053	NP
	2.0	0.972	0.146	NP	0.979	0.142	NP	0.607	0.046	0.002	0.983	0.241	NP
	3.0	0.972	0.307	0.003	0.979	0.309	0.003	0.607	0.046	0.003	0.983	0.346	0.006
	4.0	0.972	0.413	0.019	0.979	0.417	0.017	0.610	0.058	0.005	0.983	0.430	0.020
-30	0.0	0.694	0.002	NP	0.694	0.002	NP	0.185	0.000	NP	0.764	NP	NP
	1.0	0.984	0.039	NP	0.986	0.040	NP	0.410	0.019	NP	0.986	0.063	NP
	2.0	0.984	0.184	NP	0.986	0.199	NP	0.720	0.039	0.002	0.994	0.294	NP
	3.0	0.984	0.426	0.004	0.986	0.453	0.004	0.724	0.059	0.004	0.994	0.456	0.010
	4.0	0.984	0.485	0.026	0.986	0.488	0.031	0.771	0.077	0.008	0.994	0.544	0.050
-45	0.0	0.796	0.002	NP	0.790	0.002	NP	0.050	NP	NP	0.841	NP	NP
	1.0	0.989	0.065	NP	0.996	0.065	NP	0.351	0.002	NP	0.997	0.118	NP
	2.0	0.989	0.336	0.001	0.996	0.365	0.002	0.868	0.009	NP	0.997	0.394	NP
	3.0	0.989	0.546	0.019	0.996	0.616	0.022	0.868	0.056	NP	0.997	0.683	0.015
	4.0	0.989	0.626	0.062	0.996	0.640	0.078	0.887	0.137	0.005	0.997	0.752	0.093

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 4 of 16)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY MINIMUM TO 5,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 82 MOD 2 (1P)							MK 83 MOD 5 (TP)		
FIN ASSEMBLY:		MK 15							CONICAL		
MODE:		LOW DRAG			HIGH DRAG						
ARMING TIMES:		6.0	8.0	10 0	4.0	6.0	8.0	10.0	6 0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)									
-10	0.0	0.693	NP	NP	1.000	0.328	0.001	NP	0.841	0.004	NP
	1.0	0.961	0.046	NP	1.000	0.591	0.020	NP	1 000	0.053	NP
	2.0	0.974	0.217	NP	1.000	0.604	0.051	NP	1.000	0.206	0.001
	3.0	0.974	0.361	0.002	1.000	0.746	0.076	0 002	1.000	0.502	0.010
	4.0	0.974	0.406	0.016	1.000	0.789	0.087	0.002	1.000	0.567	0.027
-20	0.0	0.715	NP	NP	0.997	0.246	NP	NP	0.877	0.007	NP
	1.0	0.974	0.051	NP	1.000	0.572	0.013	NP	0.997	0.078	NP
	2.0	0.984	0.257	NP	1.000	0.758	0.047	NP	1.000	0.336	0.002
	3.0	0.984	0.383	0.007	1.000	0.864	0.086	NP	1.000	0.516	0.017
	4.0	0.984	0.436	0.023	1.000	0.896	0.126	0 004	1.000	0.636	0.041
-30	0.0	0.760	NP	NP	0.962	0.113	NP	NP	0.930	0.009	NP
	1.0	0.988	0.066	NP	1.000	0.402	0.010	NP	1.000	0.104	NP
	2.0	0.994	0.323	NP	1.000	0.830	0.047	NP	1.000	0.381	0.003
	3.0	0.994	0.474	0.012	1.000	0.953	0.113	0.002	1.000	0.634	0.024
	4.0	0.994	0.557	0.061	1.000	0.964	0.198	0 006	1.000	0.680	0.042
-45	0.0	0.832	0.001	NP	0.591	0.037	0.001	NP	0.968	0.009	NP
	1.0	0.997	0.124	NP	1.000	0.225	0.011	NP	1.000	0.172	NP
	2.0	0.997	0.436	NP	1.000	0.872	0.020	NP	1.000	0.564	0.006
	3.0	0.997	0.700	0.022	1.000	1.000	0.110	0.002	1.000	0.782	0.035
	4.0	0.997	0.765	0.103	1.000	1.000	0.402	0.012	1.000	0.860	0.125

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 5 of 16)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY 5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 81 MOD 1											
FIN ASSEMBLY:		CONICAL				MK 14 MOD 2							
MODE:						LOW DRAG				HIGH DRAG			
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS. FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
-10	0.0	0.770	0.002	NP	NP	0.769	0.003	NP	NP	0.564	0.036	0.002	NP
	1.0	0.979	0.047	NP	NP	0.974	0.043	NP	NP	0.706	0.054	0.006	NP
	2.0	0.981	0.216	0.001	NP	0.976	0.220	0.002	NP	0.813	0.065	0.008	0.001
	3.0	0.981	0.359	0.004	NP	0.976	0.338	0.004	NP	0.813	0.078	0.010	0.001
	4.0	0.981	0.420	0.023	0.001	0.976	0.422	0.023	NP	0.813	0.107	0.010	0.002
-20	0.0	0.794	0.003	NP	NP	0.792	0.003	NP	NP	0.447	0.029	NP	NP
	1.0	0.983	0.056	NP	NP	0.981	0.054	NP	NP	0.733	0.052	0.003	NP
	2.0	0.983	0.244	0.001	NP	0.987	0.255	0.001	NP	0.878	0.077	0.009	NP
	3.0	0.983	0.394	0.007	NP	0.987	0.416	0.008	NP	0.878	0.090	0.013	NP
	4.0	0.983	0.456	0.023	NP	0.987	0.452	0.032	0.001	0.878	0.153	0.016	NP
-30	0.0	0.830	0.004	NP	NP	0.830	0.004	NP	NP	0.352	0.024	NP	NP
	1.0	0.987	0.070	NP	NP	0.991	0.072	NP	NP	0.764	0.044	0.002	NP
	2.0	0.987	0.324	0.003	NP	0.991	0.338	0.002	NP	0.915	0.070	0.006	NP
	3.0	0.987	0.510	0.016	NP	0.991	0.533	0.019	NP	0.915	0.130	0.010	0.001
	4.0	0.987	0.510	0.044	0.001	0.991	0.548	0.058	NP	0.915	0.181	0.015	0.001
45	0.0	0.891	0.005	NP	NP	0.891	0.005	NP	NP	0.202	0.001	NP	NP
	1.0	0.985	0.111	NP	NP	0.997	0.123	NP	NP	0.719	0.007	NP	NP
	2.0	0.985	0.463	0.007	NP	0.997	0.502	0.003	NP	0.957	0.071	0.004	NP
	3.0	0.985	0.588	0.022	NP	0.997	0.596	0.033	NP	0.957	0.167	0.010	NP
	4.0	0.985	0.655	0.072	NP	0.997	0.676	0.078	NP	0.962	0.284	0.023	NP

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 6 of 16)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY
5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON: MK 82 MOD 2 (TP)

FIN ASSEMBLY:		CONICAL				MK 15								
MODE:						LOW DRAG				HIGH DRAG				
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0
RELEASE CONDITIONS FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)												
-10	0.0	0.808	0.008	NP	NP	0.800	0.009	NP	NP	1.000	0.550	0.013	NP	NP
	1.0	0.983	0.087	0.001	NP	0.979	0.091	NP	NP	1.000	0.791	0.074	0.007	NP
	2.0	0.986	0.273	0.004	NP	0.985	0.288	0.003	NP	1.000	0.861	0.155	0.007	NP
	3.0	0.986	0.422	0.010	NP	0.985	0.431	0.011	NP	1.000	0.866	0.219	0.009	0.005
	4.0	0.986	0.466	0.044	0.002	0.985	0.478	0.048	0.002	1.000	0.876	0.240	0.014	0.011
-20	0.0	0.821	0.008	NP	NP	0.809	0.009	NP	NP	1.000	0.475	0.013	NP	NP
	1.0	0.986	0.106	NP	NP	0.986	0.109	NP	NP	1.000	0.818	0.057	0.003	NP
	2.0	0.990	0.301	0.003	NP	0.990	0.317	0.003	NP	1.000	0.915	0.163	0.009	NP
	3.0	0.990	0.435	0.016	NP	0.990	0.451	0.018	NP	1.000	0.932	0.272	0.010	NP
	4.0	0.990	0.516	0.051	0.001	0.990	0.527	0.062	0.001	1.000	0.946	0.323	0.020	0.005
-30	0.0	0.850	0.012	NP	NP	0.850	0.012	NP	NP	0.999	0.396	0.007	NP	NP
	1.0	0.992	0.126	NP	NP	0.993	0.131	NP	NP	1.000	0.806	0.050	NP	NP
	2.0	0.992	0.354	0.004	NP	0.993	0.372	0.005	NP	1.000	0.970	0.151	0.004	NP
	3.0	0.992	0.551	0.021	NP	0.993	0.558	0.026	NP	1.000	0.975	0.334	0.018	NP
	4.0	0.992	0.612	0.063	0.001	0.993	0.619	0.079	0.001	1.000	0.987	0.453	0.033	0.004
-45	0.0	0.809	0.014	NP	NP	0.802	0.015	NP	NP	0.802	0.169	0.004	NP	NP
	1.0	0.997	0.191	NP	NP	0.998	0.196	NP	NP	1.000	0.735	0.032	NP	NP
	2.0	0.997	0.495	0.004	NP	0.998	0.526	0.006	NP	1.000	1.000	0.154	0.004	NP
	3.0	0.997	0.730	0.050	NP	0.998	0.750	0.005	NP	1.000	1.000	0.477	0.022	NP
	4.0	0.997	0.764	0.119	0.003	0.998	0.786	0.133	0.003	1.000	1.000	0.755	0.065	0.002

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11213-R2
BF 11217-R1
BF 11216-R6

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 7 of 16)

OV-10A DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY 5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON: MK 83 MOD 5 (TP)

FIN ASSEMBLY: CONICAL
MODE:

ARMING TIMES: 6.0 8.0 10.0 12.0

RELEASE CONDITIONS:

FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)			
-10	0.0	0.887	0.015	NP	NP
	1.0	1.000	0.105	0.004	NP
	2.0	1.000	0.371	0.006	NP
	3.0	1.000	0.615	0.023	NP
	4.0	1.000	0.631	0.039	0.003
-20	0.0	0.969	0.016	NP	NP
	1.0	1.000	0.129	0.003	NP
	2.0	1.000	0.418	0.008	NP
	3.0	1.000	0.611	0.022	NP
	4.0	1.000	0.668	0.075	0.004
-30	0.0	0.951	0.021	NP	NP
	1.0	1.000	0.162	NP	NP
	2.0	1.000	0.508	0.008	NP
	3.0	1.000	0.683	0.032	NP
	4.0	1.000	0.723	0.109	0.004
-45	0.0	0.967	0.028	NP	NP
	1.0	1.000	0.272	NP	NP
	2.0	1.000	0.659	0.015	NP
	3.0	1.000	0.837	0.076	NP
	4.0	1.000	0.865	0.137	0.003

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11307-R1

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 8 of 16)

OV-10D LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY

WEAPON:		MK 81 MOD 1											
FIN ASSEMBLY:		CONICAL				MK 14 MOD 2							
MODE:						LOW DRAG				HIGH DRAG			
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS: ALTITUDE (FT-MSL)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
MIN	0.0	0.809	0.007	NP	NP	0.793	0.018	NP	NP	0.385	0.026	0.001	NP
TO	1.0	0.947	0.064	NP	NP	0.937	0.066	NP	NP	0.428	0.037	0.002	NP
5,000	2.0	0.954	0.137	0.001	NP	0.947	0.139	0.001	NP	0.428	0.038	0.002	NP
	3.0	0.959	0.200	0.003	NP	0.956	0.188	0.003	NP	0.428	0.040	0.002	NP
	4.0	0.959	0.256	0.005	NP	0.956	0.232	0.005	NP	0.428	0.040	0.002	NP
5,001	0.0	0.804	0.028	NP	NP	0.800	0.026	0.001	NP	0.619	0.057	0.007	NP
TO	1.0	0.973	0.101	0.001	NP	0.967	0.105	0.001	NP	0.677	0.070	0.013	NP
10,000	2.0	0.973	0.265	0.003	NP	0.969	0.264	0.003	NP	0.677	0.070	0.015	0.001
	3.0	0.976	0.344	0.009	NP	0.974	0.341	0.011	NP	0.677	0.075	0.015	0.001
	4.0	0.976	0.395	0.017	0.001	0.974	0.380	0.019	0.001	0.677	0.075	0.015	0.001

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 9 of 16)

OV-10D LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY

WEAPON:		MK 82 MOD 2 (TP)											
FIN ASSEMBLY:		CONICAL				MK 15							
MODE:						LOW DRAG				HIGH DRAG			
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0
RELEASE CONDITIONS:													
ALTITUDE (FT-MSL)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
MIN	0.0	0.840	0.016	NP	NP	0.833	0.016	NP	NP	0.440	0.008	NP	NP
TO	1.0	0.954	0.103	NP	NP	0.949	0.105	NP	NP	0.566	0.026	NP	NP
5,000	2.0	0.962	0.212	NP	NP	0.960	0.218	NP	NP	0.620	0.045	NP	NP
	3.0	0.967	0.291	0.005	NP	0.966	0.295	0.006	NP	0.657	0.053	NP	NP
	4.0	0.967	0.341	0.012	NP	0.966	0.343	0.012	NP	0.657	0.055	NP	NP
5,001	0.0	0.893	0.064	0.001	NP	0.893	0.066	0.002	NP	0.612	0.037	0.007	NP
TO	1.0	0.974	0.188	0.005	NP	0.972	0.175	0.005	NP	0.743	0.083	0.007	NP
10,000	2.0	0.978	0.321	0.011	NP	0.977	0.310	0.010	NP	0.794	0.124	0.007	0.004
	3.0	0.981	0.384	0.020	0.001	0.981	0.374	0.021	0.001	0.826	0.147	0.007	0.006
	4.0	0.981	0.413	0.033	0.005	0.981	0.415	0.035	0.004	0.826	0.156	0.007	0.010

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11213-R2
BF 11217-R1
BF 11216-R6

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 10 of 16)

OV-10D LEVEL RELEASE WITH A 2G LEVEL BREAKAWAY RECOVERY

WEAPON: MK 83 MOD 5 (TP)

FIN ASSEMBLY: CONICAL
MODE:

ARMING TIMES: 5.0 8.0 10.0 12.0

RELEASE CONDITIONS:

ALTITUDE (FT-MSL)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)			
MIN	0.0	0.995	0.050	NP	NP
TO	1.0	0.995	0.188	0.002	NP
5,000	2.0	0.999	0.367	0.007	NP
	3.0	1.000	0.506	0.020	NP
	4.0	1.000	0.552	0.031	NP
5,001	0.0	1.000	0.125	0.005	NP
TO	1.0	1.000	0.318	0.011	NP
10,000	2.0	1.000	0.477	0.016	NP
	3.0	1.000	0.597	0.064	0.005
	4.0	1.000	0.641	0.073	0.008

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11307-R1

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 11 of 16)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY MINIMUM TO 5,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 81 MOD 1									MK 82 MOD 2 (TP)		
FIN ASSEMBLY:		CONICAL			MK 14 MOD 2						CONICAL		
MODE:					LOW DRAG			HIGH DRAG					
ARMING TIMES:		6.0	8.0	10.0	6.0	8.0	10.0	4.0	6.0	8.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
-10	0.0	0.619	0.001	NP	0.604	0.001	NP	0.315	0.019	0.001	0.662	NP	NP
	1.0	0.952	0.018	NP	0.949	0.021	NP	0.387	0.031	0.001	0.956	0.032	NP
	2.0	0.965	0.110	NP	0.969	0.113	NP	0.500	0.035	0.002	0.972	0.195	NP
	3.0	0.965	0.261	0.002	0.969	0.267	0.002	0.500	0.039	0.005	0.972	0.351	0.001
	4.0	0.965	0.303	0.008	0.969	0.306	0.010	0.500	0.049	0.005	0.972	0.398	0.014
-20	0.0	0.610	0.002	NP	0.615	0.002	NP	0.254	0.014	NP	0.690	NP	NP
	1.0	0.966	0.027	NP	0.966	0.028	NP	0.399	0.028	NP	0.967	0.046	NP
	2.0	0.978	0.135	NP	0.974	0.143	NP	0.592	0.042	0.001	0.983	0.241	NP
	3.0	0.978	0.299	0.003	0.974	0.299	0.003	0.592	0.046	0.002	0.983	0.407	0.003
	4.0	0.978	0.410	0.013	0.974	0.412	0.014	0.610	0.057	0.004	0.983	0.422	0.021
-30	0.0	0.663	0.002	NP	0.642	0.002	NP	0.146	0.006	NP	0.741	NP	NP
	1.0	0.986	0.036	NP	0.983	0.037	NP	0.385	0.015	NP	0.985	0.063	NP
	2.0	0.986	0.179	NP	0.991	0.189	NP	0.704	0.034	NP	0.993	0.325	NP
	3.0	0.986	0.435	0.004	0.991	0.452	0.004	0.722	0.057	0.003	0.993	0.468	0.011
	4.0	0.986	0.478	0.029	0.991	0.483	0.027	0.771	0.075	0.007	0.993	0.546	0.057
-45	0.0	0.754	0.002	NP	0.723	0.002	NP	0.053	NP	NP	0.807	NP	NP
	1.0	0.996	0.060	NP	1.000	0.061	NP	0.313	0.001	NP	0.998	0.118	NP
	2.0	0.996	0.315	0.001	1.000	0.328	0.002	0.850	0.008	NP	0.998	0.449	NP
	3.0	0.996	0.596	0.015	1.000	0.670	0.019	0.858	0.043	NP	0.998	0.694	0.024
	4.0	0.996	0.624	0.071	1.000	0.670	0.084	0.887	0.135	0.004	0.998	0.759	0.108

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2
BF 11213-R2

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 12 of 16)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY MINIMUM TO 5,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 82 MOD 2 (TP)							MK 83 MOD 5 (TP)		
FIN ASSEMBLY:		MK 15							CONICAL		
MODE:		LOW DRAG			HIGH DRAG						
ARMING TIMES:		6.0	8.0	10.0	4.0	6.0	8.0	10.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)									
-10	0.0	0.668	NP	NP	1.000	0.301	0.001	NP	0.886	0.005	NP
	1.0	0.957	0.031	NP	1.000	0.557	0.017	NP	1.000	0.062	NP
	2.0	0.974	0.181	NP	1.000	0.672	0.046	NP	1.000	0.308	0.001
	3.0	0.974	0.346	0.001	1.000	0.731	0.069	NP	1.000	0.524	0.010
	4.0	0.974	0.395	0.013	1.000	0.785	0.082	NP	1.000	0.615	0.030
-20	0.0	0.682	NP	NP	0.992	0.192	NP	NP	0.929	0.007	NP
	1.0	0.970	0.048	NP	1.000	0.512	0.010	NP	0.996	0.075	NP
	2.0	0.983	0.231	NP	1.000	0.735	0.039	NP	1.000	0.368	0.002
	3.0	0.983	0.421	0.003	1.000	0.851	0.078	NP	1.000	0.501	0.016
	4.0	0.983	0.437	0.022	1.000	0.895	0.115	0.005	1.000	0.647	0.042
-30	0.0	0.738	NP	NP	0.880	0.071	0.001	NP	0.957	0.008	NP
	1.0	0.985	0.066	NP	1.000	0.391	0.006	NP	1.000	0.116	NP
	2.0	0.994	0.327	NP	1.000	0.799	0.036	NP	1.000	0.454	0.004
	3.0	0.994	0.484	0.010	1.000	0.943	0.096	0.001	1.000	0.685	0.025
	4.0	0.994	0.550	0.058	1.000	0.964	0.177	0.003	1.000	0.712	0.076
-45	0.0	0.805	NP	NP	0.510	0.027	NP	NP	0.982	0.010	NP
	1.0	0.998	0.117	NP	1.000	0.155	0.007	NP	1.000	0.204	NP
	2.0	1.000	0.486	NP	1.000	0.792	0.022	NP	1.000	0.580	0.006
	3.0	1.000	0.709	0.026	1.000	1.000	0.079	0.003	1.000	0.813	0.048
	4.0	1.000	0.777	0.128	1.000	1.000	0.364	0.007	1.000	0.879	0.118

NOTES:
1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11217-R1
BF 11216-R6
BF 11307-R1

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 13 of 16)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY 5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 81 MOD 1											
FIN ASSEMBLY:		CONICAL				MK 14 MOD 2							
MODE:						LOW DRAG				HIGH DRAG			
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)											
-10	0.0	0.848	0.006	NP	NP	0.843	0.008	NP	NP	0.501	0.034	0.001	NP
	1.0	0.976	0.071	NP	NP	0.978	0.073	NP	NP	0.676	0.048	0.005	NP
	2.0	0.976	0.274	0.001	NP	0.981	0.273	0.001	NP	0.797	0.061	0.007	0.001
	3.0	0.976	0.334	0.006	NP	0.981	0.345	0.007	NP	0.797	0.071	0.008	0.001
	4.0	0.976	0.423	0.022	NP	0.981	0.417	0.020	NP	0.797	0.101	0.008	0.001
-20	0.0	0.794	0.004	NP	NP	0.792	0.004	NP	NP	0.373	0.028	NP	NP
	1.0	0.979	0.057	NP	NP	0.984	0.063	NP	NP	0.693	0.049	0.003	NP
	2.0	0.986	0.260	0.001	NP	0.986	0.269	0.001	NP	0.872	0.072	0.008	NP
	3.0	0.986	0.403	0.005	NP	0.986	0.433	0.007	NP	0.872	0.085	0.011	NP
	4.0	0.986	0.431	0.030	NP	0.986	0.468	0.028	NP	0.872	0.146	0.014	NP
-30	0.0	0.814	0.004	NP	NP	0.810	0.004	NP	NP	0.301	0.018	NP	NP
	1.0	0.990	0.071	NP	NP	0.994	0.078	NP	NP	0.705	0.039	0.002	NP
	2.0	0.990	0.319	0.001	NP	0.904	0.333	0.002	NP	0.914	0.065	0.006	NP
	3.0	0.990	0.512	0.016	NP	0.994	0.520	0.016	NP	0.914	0.124	0.009	NP
	4.0	0.990	0.515	0.044	NP	0.994	0.571	0.051	NP	0.914	0.174	0.013	NP
-45	0.0	0.879	0.004	NP	NP	0.875	0.004	NP	NP	0.140	0.001	NP	NP
	1.0	0.998	0.116	NP	NP	1.000	0.116	NP	NP	0.632	0.004	NP	NP
	2.0	0.998	0.482	0.007	NP	1.000	0.513	0.003	NP	0.955	0.046	0.002	NP
	3.0	0.998	0.593	0.034	NP	1.000	0.632	0.037	NP	0.955	0.158	0.008	NP
	4.0	0.998	0.663	0.075	0.001	1.000	0.675	0.110	0.001	0.962	0.279	0.020	NP

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11102-R21A
BF 11105-R1
BF 11103-R2

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 14 of 16)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY 5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON:		MK 82 MOD 2 (TP)												
FIN ASSEMBLY:		CONICAL				MK 15								
MODE:						LOW DRAG				HIGH DRAG				
ARMING TIMES:		6.0	8.0	10.0	12.0	6.0	8.0	10.0	12.0	4.0	6.0	8.0	10.0	12.0
RELEASE CONDITIONS: FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)												
-10	0.0	0.852	0.010	NP	NP	0.854	0.012	NP	NP	1.000	0.533	0.017	NP	NP
	1.0	0.981	0.103	0.001	NP	0.981	0.104	0.001	NP	1.000	0.783	0.070	0.005	NP
	2.0	0.984	0.292	0.006	NP	0.985	0.203	0.006	NP	1.000	0.853	0.150	0.010	NP
	3.0	0.984	0.424	0.014	NP	0.985	0.430	0.015	NP	1.000	0.860	0.206	0.010	0.003
	4.0	0.984	0.470	0.046	0.002	0.985	0.476	0.046	0.002	1.000	0.872	0.231	0.012	0.007
-20	0.0	0.814	0.008	NP	NP	0.809	0.009	NP	NP	1.000	0.426	0.011	NP	NP
	1.0	0.982	0.009	NP	NP	0.983	0.035	NP	NP	1.000	0.773	0.044	NP	NP
	2.0	0.990	0.331	0.004	NP	0.991	0.343	0.004	NP	1.000	0.909	0.136	0.006	NP
	3.0	0.990	0.461	0.018	NP	0.991	0.430	0.017	NP	1.000	0.927	0.250	0.013	NP
	4.0	0.990	0.514	0.062	0.001	0.991	0.520	0.062	0.001	1.000	0.945	0.311	0.015	0.004
-30	0.0	0.824	0.010	NP	NP	0.828	0.011	NP	NP	0.994	0.321	0.005	NP	NP
	1.0	0.992	0.116	NP	NP	0.992	0.122	NP	NP	1.000	0.763	0.036	NP	NP
	2.0	0.995	0.382	0.003	NP	0.997	0.405	0.003	NP	1.000	0.963	0.122	0.003	NP
	3.0	0.995	0.552	0.021	NP	0.997	0.560	0.023	NP	1.000	0.973	0.296	0.016	NP
	4.0	0.995	0.612	0.080	0.001	0.997	0.623	0.087	0.001	1.000	0.987	0.437	0.026	0.003
-45	0.0	0.686	0.012	NP	NP	0.882	0.012	NP	NP	0.702	0.086	0.003	NP	NP
	1.0	0.999	0.192	NP	NP	0.999	0.202	NP	NP	1.000	0.560	0.016	NP	NP
	2.0	0.999	0.531	0.005	NP	0.999	0.558	0.006	NP	1.000	0.973	0.094	0.002	NP
	3.0	0.999	0.753	0.066	NP	0.999	0.771	0.065	NP	1.000	1.000	0.417	0.013	NP
	4.0	0.999	0.779	0.134	0.002	0.999	0.799	0.109	0.002	1.000	1.000	0.722	0.050	0.001

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11213-R2
BF 11217-R1
BF 11216-R6

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 15 of 16)

OV-10D DIVE RELEASE WITH A 3G LEVEL BREAKAWAY RECOVERY 5,001 TO 10,000 FT-MSL RELEASE ALTITUDE

WEAPON: MK 83 MOD 5 (TP)

FIN ASSEMBLY: CONICAL
MODE:

ARMING TIMES: 6.0 8.0 10.0 12.0

RELEASE CONDITIONS:

FLIGHT PATH ANGLE (DEG)	STICK (SEC)	PROBABILITY OF HIT GIVEN EARLY BURST (PH/EB)			
-10	0.0	1.000	0.022	NP	NP
	1.0	1.000	0.115	0.004	NP
	2.0	1.000	0.390	0.014	NP
	3.0	1.000	0.614	0.029	0.003
	4.0	1.000	0.624	0.050	0.006
-20	0.0	0.988	0.020	NP	NP
	1.0	1.000	0.145	0.001	NP
	2.0	1.000	0.459	0.008	NP
	3.0	1.000	0.597	0.033	NP
	4.0	1.000	0.675	0.108	0.004
-30	0.0	0.983	0.021	NP	NP
	1.0	1.000	0.178	NP	NP
	2.0	1.000	0.551	0.007	NP
	3.0	1.000	0.712	0.035	NP
	4.0	1.000	0.737	0.115	0.004
-45	0.0	0.900	0.033	NP	NP
	1.0	1.000	0.274	NP	NP
	2.0	1.000	0.701	0.016	NP
	3.0	1.000	0.865	0.091	NP
	4.0	1.000	0.886	0.218	0.004

NOTES: 1. Release velocities are 200 and 250 KTAS.
2. Refer to stores limitations and fuze descriptions for KIAS restrictions.

BF 11307-R1

Figure 4-41. Probability of Hit in the Event of Early Burst (Sheet 16 of 16)

CHAPTER 5

Additional Weapons Descriptions

5.1 ADDITIONAL WEAPONS

5.1.1 Introduction. The weapons described in the following paragraphs are not authorized for carriage or release from the OV-10; the data are provided for information only.

5.2 CBU-72/B FUEL AIR EXPLOSIVE (FAE)

5.2.1 Description. The CBU-72/B FAE (Figure 5-1) is designed as a free-fall unguided weapon for use against a variety of targets. It is effective against defensive positions, light material targets, clearing foliage, booby trapped areas, and for clearing helicopter landing zones. The primary damaging mechanism is the relatively long duration of overpressure, roughly equivalent to three Mk 82 (500 pound) bombs.

The CBU-72/B FAE is received in all-up round configuration and consists of a SUU-49A/B dispenser, Mk 339 mechanical time fuze which opens the dispenser at a preselected time, and three BLU-73A/B FAE bomb canisters.

5.3 MK 20 CLUSTER BOMB (ROCKEYE)

5.3.1 Description. The Mk 20-series Rockeye (Figure 5-2) is designed as a free-fall dispenser/cluster bomb weapon for use against a variety of area targets. It is effective against trucks, radar vans, missile sites, fuel storage tanks, surface ships, and snorkeling submarines. The dispenser contains 247 bomblets that are heavier and penetrate thicker armor than those found in the CBU-59 APAM weapon, but lack the pop-out feature for optimum antipersonnel effects.

The Mk 20 Rockeye is received in an all-up round configuration and consists of a Mk 7 dispenser, either an FMU-140/B dispenser proximity fuze or a Mk 339 mechanical time fuze which opens the dispenser at a preselected setting, and 247 Mk 118 Mod 0/1 bomblets. The Mod 6 and 7 dispensers have a thermal protective coating to improve cook-off protection in the event of a fire.

5.3.2 Mk 7 Dispenser. The Mk 7 series dispenser is a one-piece container enclosing the individual bomblets. It has stabilizing fins that extend at weapon release and a linear shape charge that separates the container longitudinally when the fuze functions, dispersing the bomblets.

The FMU-140/B dispenser proximity fuze is a self-powered, range-gated Doppler radar which functions as a radar altimeter and timing device. It has two preflight selectable (ARM TIME and HOF) switches that provide 10 HOF settings (primary mode) from 300 to 3,000 feet with five arm times from 1.2 to 10.0 seconds or a 1.2-second arm time (option mode). The primary mode also has a 300-foot HOF built-in backup.

The Mk 339 mechanical time fuze is factory set to provide an in-flight option of either 1.2-second (primary mode) or 4.0-second (option mode) functioning time. The 1.2-second functioning time is used for low-altitude releases to ensure that the bomblets have adequate time of fall for proper dispersal prior to impact. The 4.0-second functioning time is used for high-altitude releases to minimize the effects of wind and required mil lead. The factory set functioning times may be changed (preflight) to other times more conducive to higher altitude release or loft delivery (e.g., 6, 8, 10, 12, ..., etc.).

The Mk 20 Mod 2 is received with the Mk 339 mechanical time fuze preset at 4.0-second (no option) functioning time that is stenciled on the nose fairing of the dispenser. Other Mods provide both a 1.2-second (primary) and a 4.0-second (option) functioning time.

Except for the Mod 2, two fuze arming wires (primary and option) are installed in conduits that are slotted at various intervals to allow positioning of the arming wire extractor to correspond with the placement of the arming solenoids on different suspension equipment. All Mods have a tail fin actuating wire that is always positively armed to the suspension equipment at a designated point.

Characteristics	CBU-72/B
Length (Inches)	91.7
Diameter (Inches)	14.0
Loaded Weight (Pounds)	520.0
Suspension (Inches)	14.0
Number of Bomblets	3

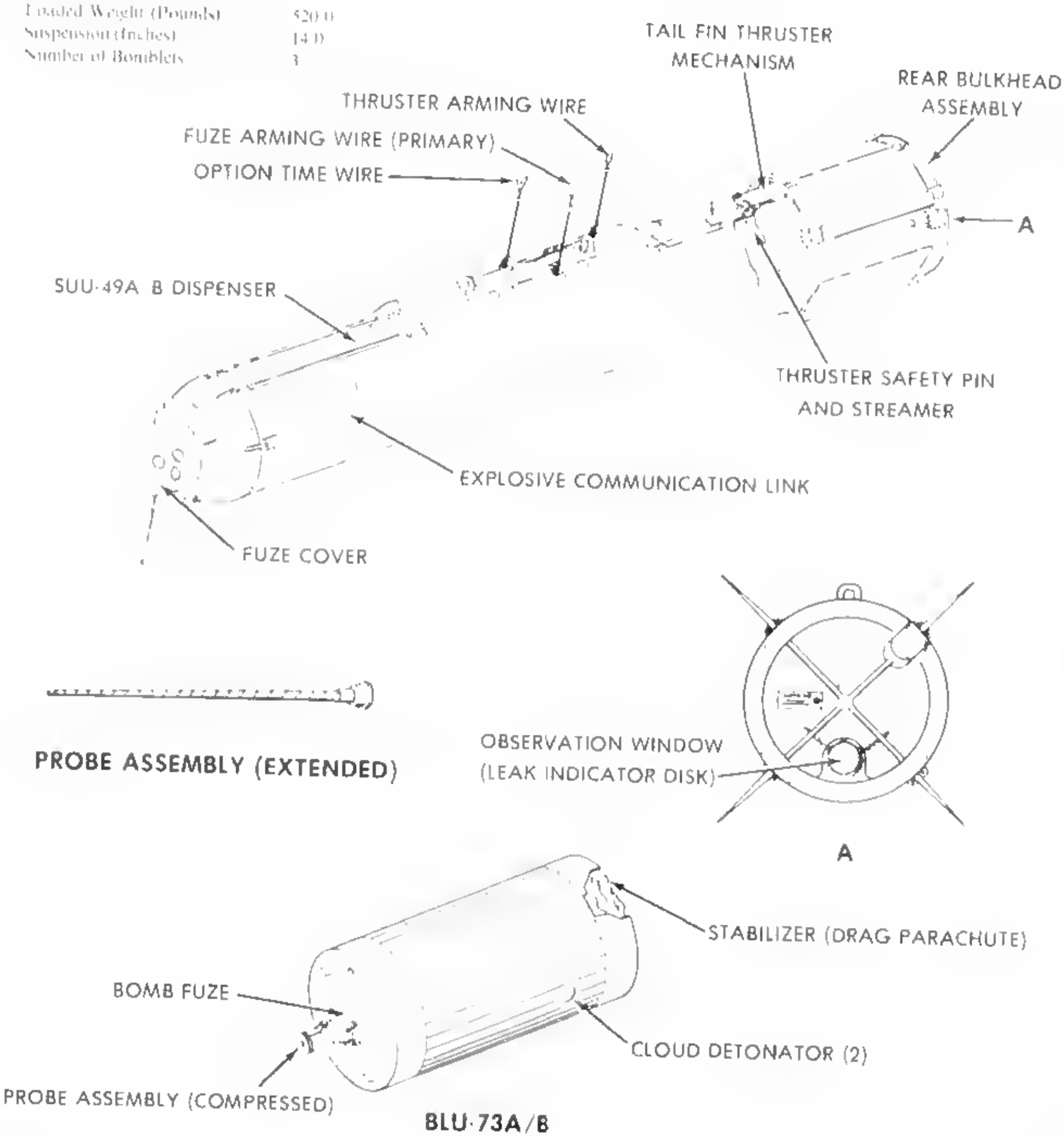
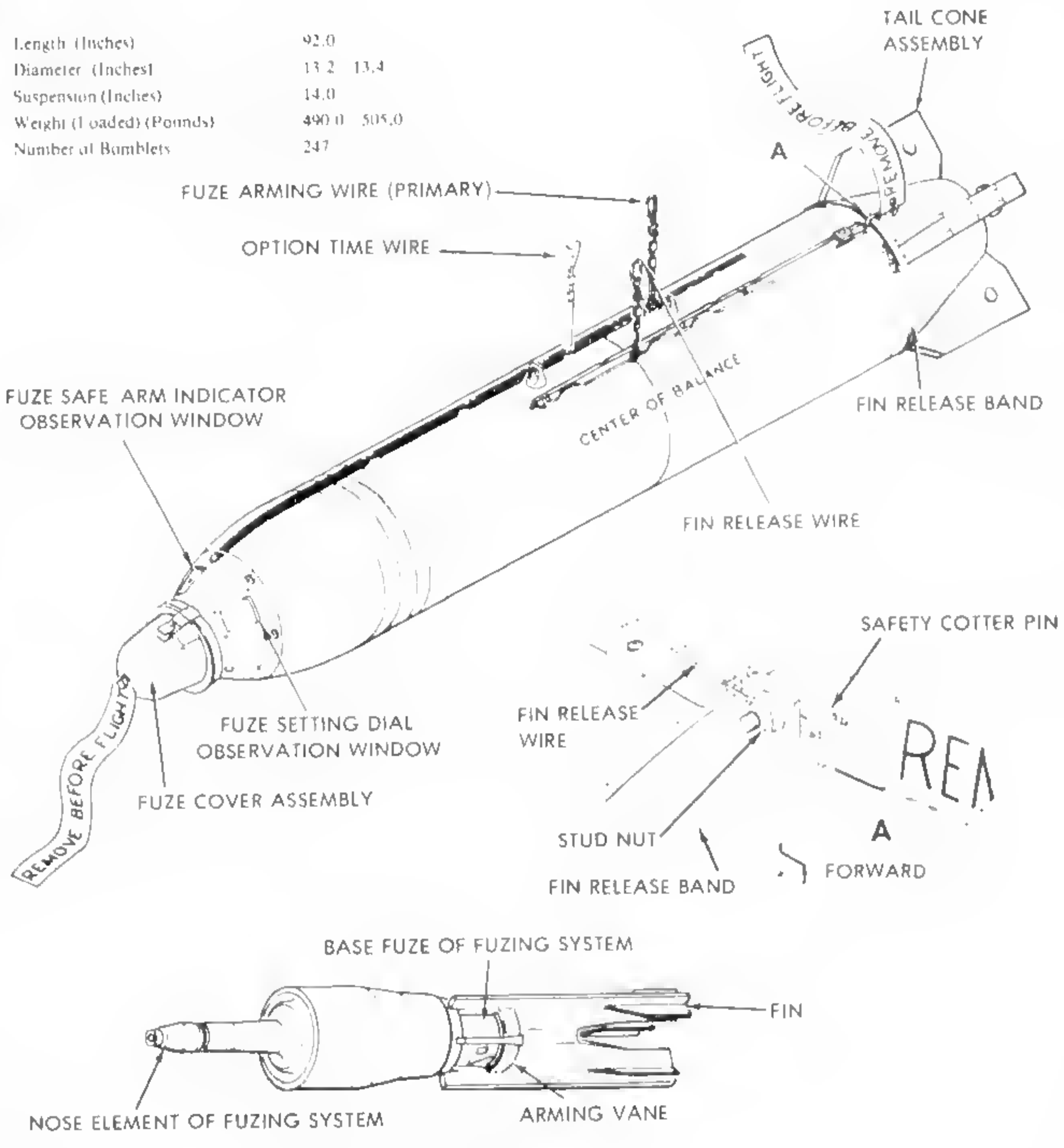


Figure 5-1. CBU-72/B Fuel-Air Explosive Bomb Cluster (FAE)

Characteristics

Length (Inches)	92.0
Diameter (Inches)	13.2 - 13.4
Suspension (Inches)	14.0
Weight (Loaded) (Pounds)	490.0 - 505.0
Number of Bomblets	247



MK 118 MOD 0/1 BOMBLET

Figure 5-2. Mk 20 Series Antitank Bomb Cluster (Rockeye)

Placement of the extractor for the primary and option mode wires is labeled on the dispenser for most aircraft. This placement/positioning of the extractors was determined by the aircraft arming solenoid location and circuitry. For the primary mode (1.2 seconds), only the primary wire is withdrawn at release. To select the option mode (4.0 seconds), both fuze arming wires must be withdrawn. Failure to withdraw the primary wire during any normal release will cause the weapon to dud as it keeps the fuze impeller from turning.

5.3.3 Mk 118 Mod 0/1 Antitank Bomblet. The Mk 118 bomblet has a small shaped-charge warhead that is capable of penetrating 6 inches of armor plate. It uses a fuzing system that has a small tail mounted arming vane. The tail fuze that arms the bomblet after dispersal from the dispenser detonates the bomblets after a short delay on impact with soft targets. The nose element of the fuzing system detonates the bomblet instantaneously, maximizing the shaped-charge effect on impact with hard targets (steel, concrete, etc.). The discriminating feature of the fuzing system permits penetration of light materials (vegetation, camouflage nets, light plywood, etc.) with a delayed detonation until the bomblet impacts with a more solid material. Minimum airspeed of dispersed bomblets to complete the arming cycle is 225 KIAS.

The Mod 0 antitank bomblets arm approximately 1.5 seconds after dispenser opening while the Mod 1 bomblets arm 0.5 second after dispenser opening. The Mod 1 bomblets are loaded in the Mk 20 Mod 4 bomb clusters only.

5.4 CBU-59 CLUSTER BOMB (APAM)

5.4.1 Description. The CBU-59 APAM (Figure 5-3) is designed as a free-fall dispenser/cluster bomb weapon that is highly effective against both personnel and lightly armored equipment under a wide variety of terrain conditions. The dispenser contains 717 bomblets that are lighter and penetrate less armor than those found in the Mk 20 Rockeye weapon, but they are extremely effective as antipersonnel weapons because of the pop-out feature of the bomblet on impacting soft targets.

The CBU-59 APAM is available in two models (-/B, -A/B) of which the -A/B has Air Weapons Change (AWC) 283 incorporated. Both models are received in an all-up-round (AUR) configuration that consists of a Mk 7 Mod 3 dispenser, Mk 339 mechanical time fuze which opens the dispenser at a preselected time, and 717 BLU-77/B bomblets. APAM is distinguished from the Mk 20 Rockeye by the black three-bar lightning-bolt insignia painted on each side of the dispenser.

5.4.1.1 BLU-77/B Target-Discriminating Shaped-Charge Airburst Bomblet. The BLU-77/B bomblet incorporates a shaped-charge warhead which is capable of penetrating light armor. It also incorporates a controlled-fragmentation warhead when used against soft targets. In the hard-target mode, the forward portion of the bomblet is crushed and the warhead is detonated instantaneously. In the soft-target mode, the bomblet buries itself in the soil and its aft portion is ejected rearwards into the air (pop-out) 2.0 to 10.0 feet and detonates, maximizing the fragmentation effect.

The bomblet is armed by ram air entering the arming mechanism nozzle which in turn operates a flutter vane. Less than 2.0 seconds of air travel is required for the bomblet to arm. A minimum airspeed of 375 KIAS is required at dispenser release to ensure complete bomblet arming prior to impact.

5.5 BGM-71 SERIES TOW MISSILE SYSTEM

5.5.1 Description. The BGM-71 series TOW missile (Figure 5-4) is a tube-launched, optically-tracked, wire command linked weapon system. The system is received and loaded as an all-up-round (AUR) that consists of a guided missile and missile container. The missile container doubles as an environmental stowage container and aircraft launch tube with helicopter suspension achieved through the use of the TOW missile launcher. The missile, launch tube, launcher, and aircraft avionics interface is an adaption of the infantry TOW system. The missile is capable of penetrating most armored/hardened targets encountered. Upon launch, two rocket motors provide the propulsion required for flight. A launch motor provides the thrust necessary to eject the missile from the launch tube. Shortly there-after, a flight motor accelerates the missile to the velocity required to complete the flight. The missile then coasts to the target. Aerodynamic flight control is provided by four wings and four moveable control surfaces, all of which are folded into the missile during storage and extended and latched by spring-loaded mechanisms when the missile leaves the launch tube. The wings that are mounted in the center section of the missile provide aerodynamic stability and lift, while control surfaces at the aft end of the missile provide steering. The control surfaces are actuated by a compressed gas electromechanical actuator system that responds to signals from the missile electronics. Gas power is provided by an onboard supply of compressed helium. Electrical power is provided by onboard batteries.

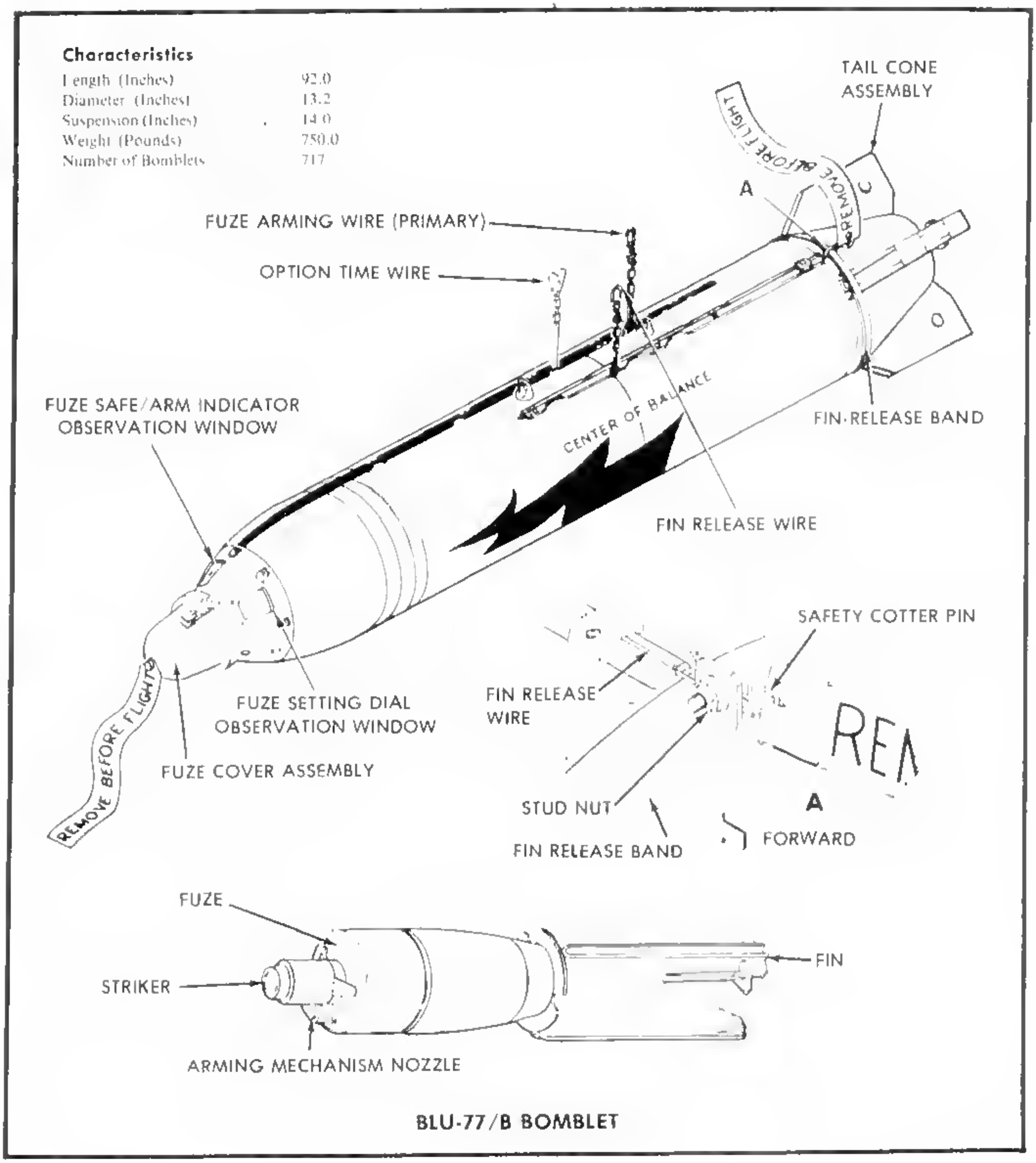
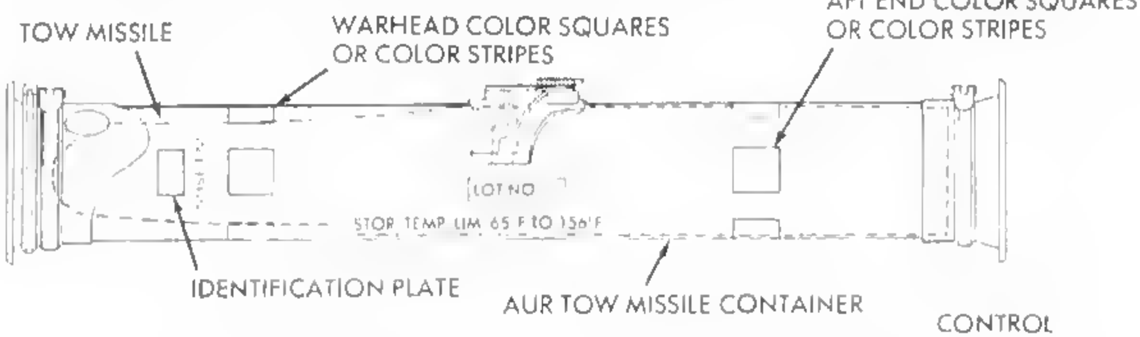


Figure 5-3. CBU-59/B Antipersonnel/Antimaterial Bomb Cluster (APAM)

Physical/Functional Characteristics	BGM-71 Series -71A (TOW)	-71A-1 (TOW) (Extended)	-71C (ITOW)	-71D (TOW 2)	-71E (TOW 2A)
Missile Weight (lbs)	41	41	41	46	49
Launch Tube Weight (lbs)	11	11	11	11	11
AUR Weight (lbs)	52	52	52	57	60
AUR Diameter (inches)	8	8	8	8	8
AUR Length (inches)	50	50	50	50	50
Max Range (meters)	3,000	3,750	3,750	3,750	3,750
Launch Motor					
Distance (ft)	25	25	25	25	25
Velocity (f/s)	225	225	225	225	225
Flight Motor Burntime (sec)	1.5	1.5	1.5	1.5	1.5

Notes: (1) Missile length, weight and diameter includes missile container

(2) Use sum of warhead and flight motor explosive weight for Quanity Distance purposes.



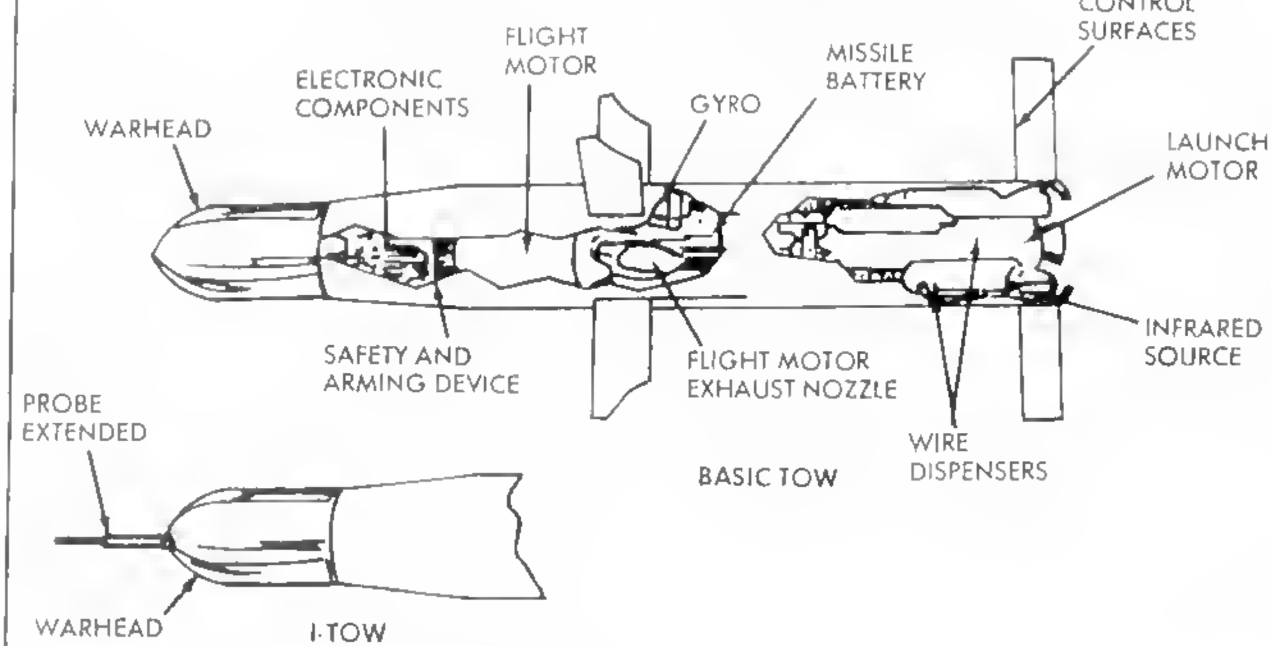


Figure 5-4. BGM-71 Series TOW Missile (Sheet 1 of 6)

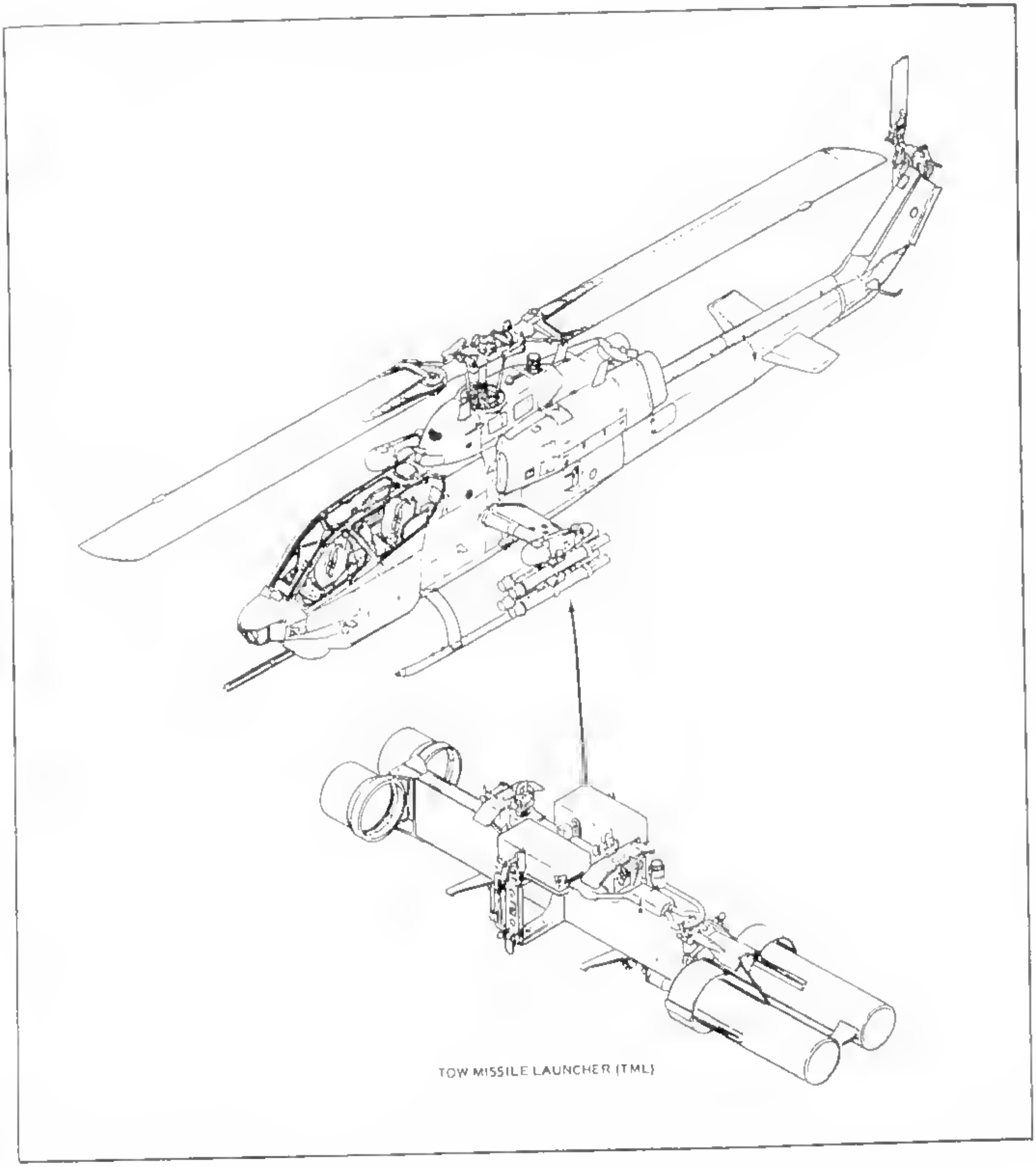


Figure 5-4. BGM-71 Series TOW Missile(Sheet 2 of 6)

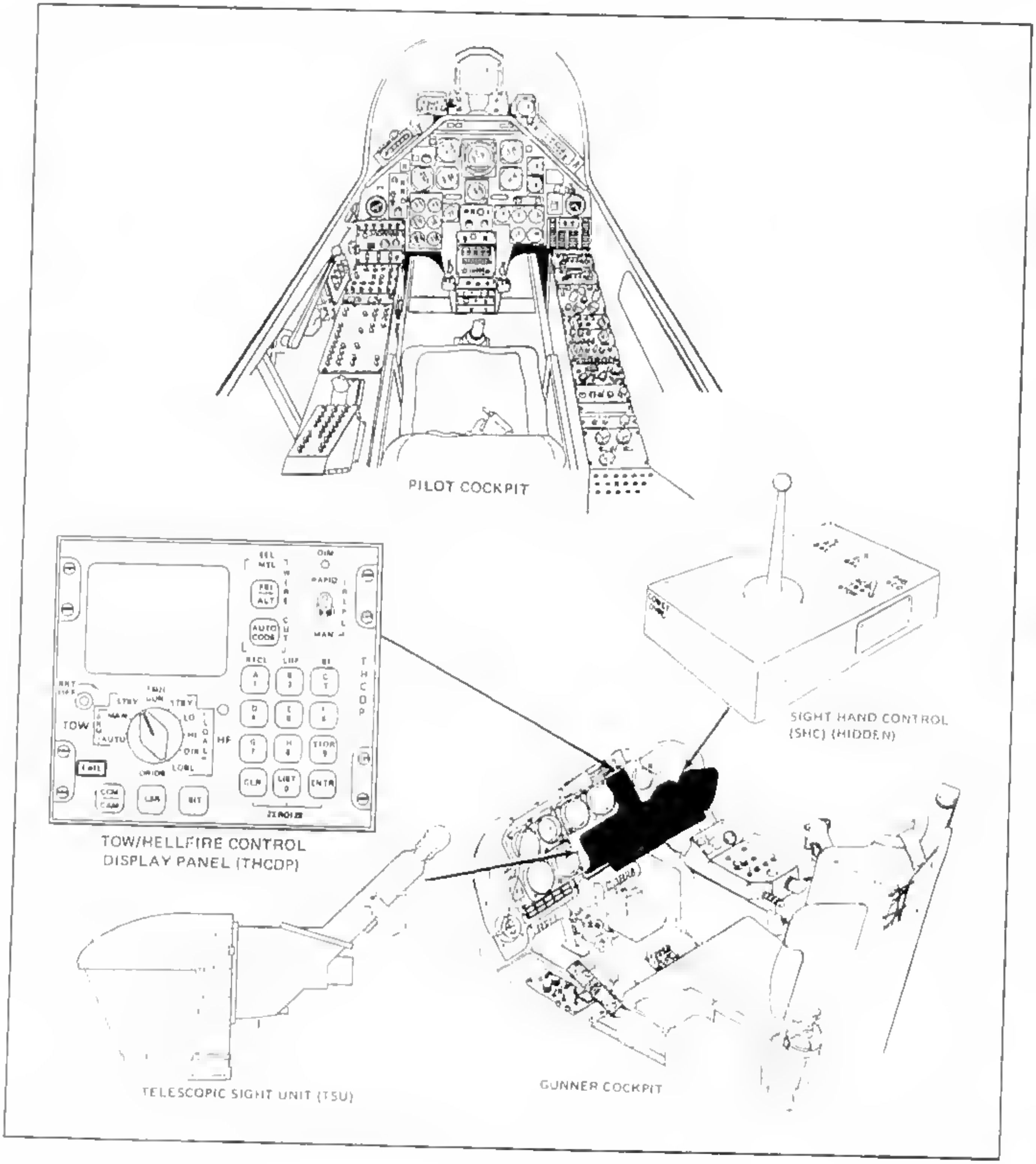


Figure 5-4. BGM-71 Series TOW Missile (Sheet 3 of 6)

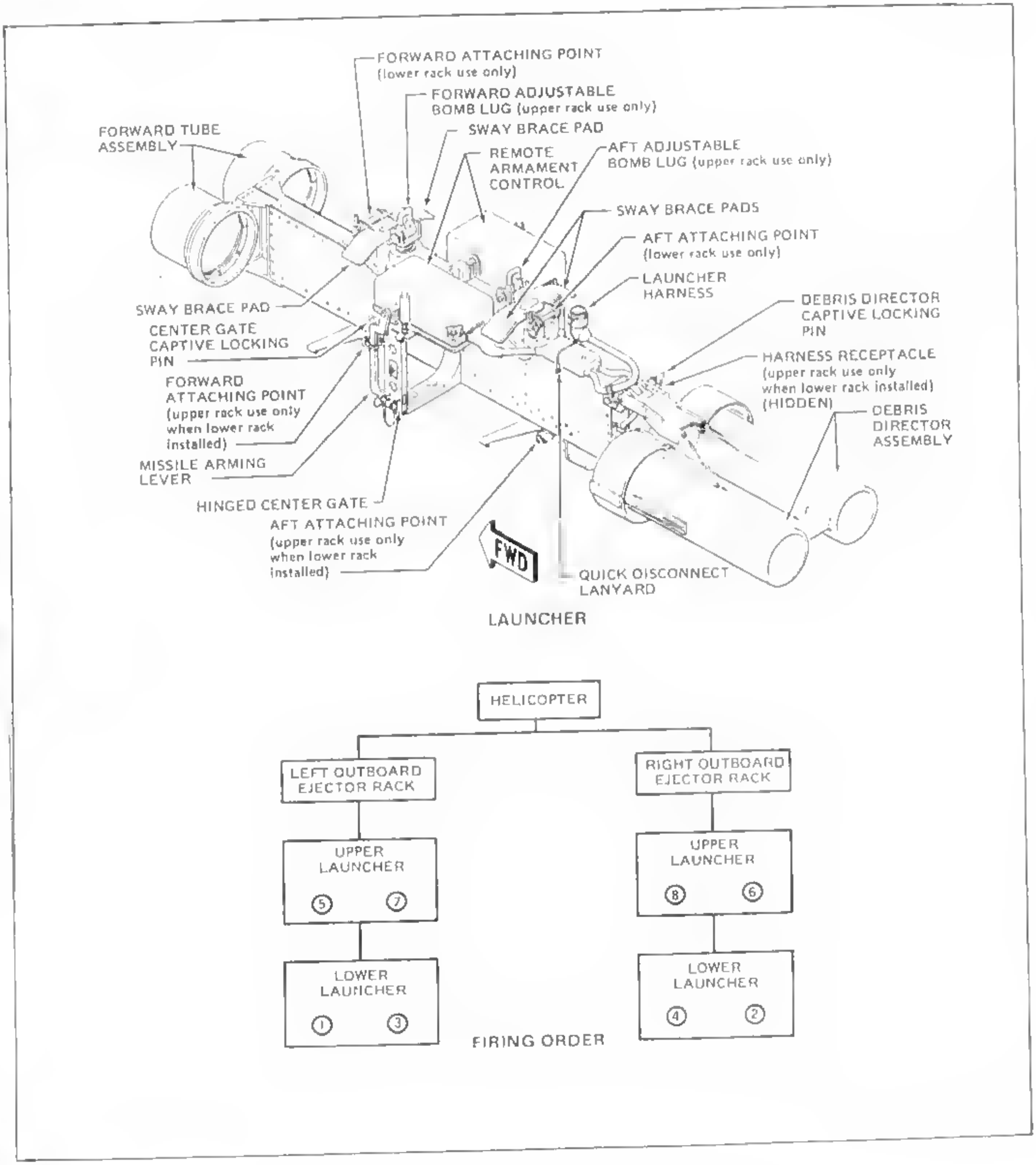


Figure 5-4. BGM-71 Series TOW Missile (Sheet 4 of 6)

BGM SERIES	WARHEAD	SAFE/ ARM	EXPLOSIVE	COPPER LINER	CRUSH SWITCH	FEATURES
-71A/71A-1 (TOW)	HE, M207 (5-inch diameter)	M114	OCTOL/ PBX	60° Cone	Ogive	Functions at obliquity angles to 65°; resists deformation given brush or foliage; standoff detonation distance of approximately 4.7 inches; detonation less than 100 microseconds after ogive crush.
-71C (ITOW)	HE, M207E1 (5-inch diameter)	M114	LX-14/ PBXN-5, Type I	42°/30° Tandem Cones	Probe/ Ogive	Improved warhead initiation; extensible probe stowed until launch and designed with crush switch; standoff detonation distance of approximately 14.3 inches; improves damage effectivity.
-71D (TOW 2)	HE, M207E2 (6-inch diameter)	M114	Lx-14/ PBXN-5, Type I	Multiple Angle	Probe/ Ogive	Extensible probe stowed until launch and designed with crush switch; standoff detonation distance of approximately 14.3 inches, improves damage effectivity.
-71E (TOW 2A)	HE, M207E5 (6-inch diameter)	M114 (2, precursor and primary)	LX-14/ PBXN-5, Type I	Multiple Angle	Probe/ Ogive	Extensible probe designed with precursor (1.5-inch diameter shape charge) for reactive armor detonation; 500 microsecond delay to primary warhead detonation.

Figure 5-4. BGM-71 Series TOW Missile (Sheet 5 of 6)

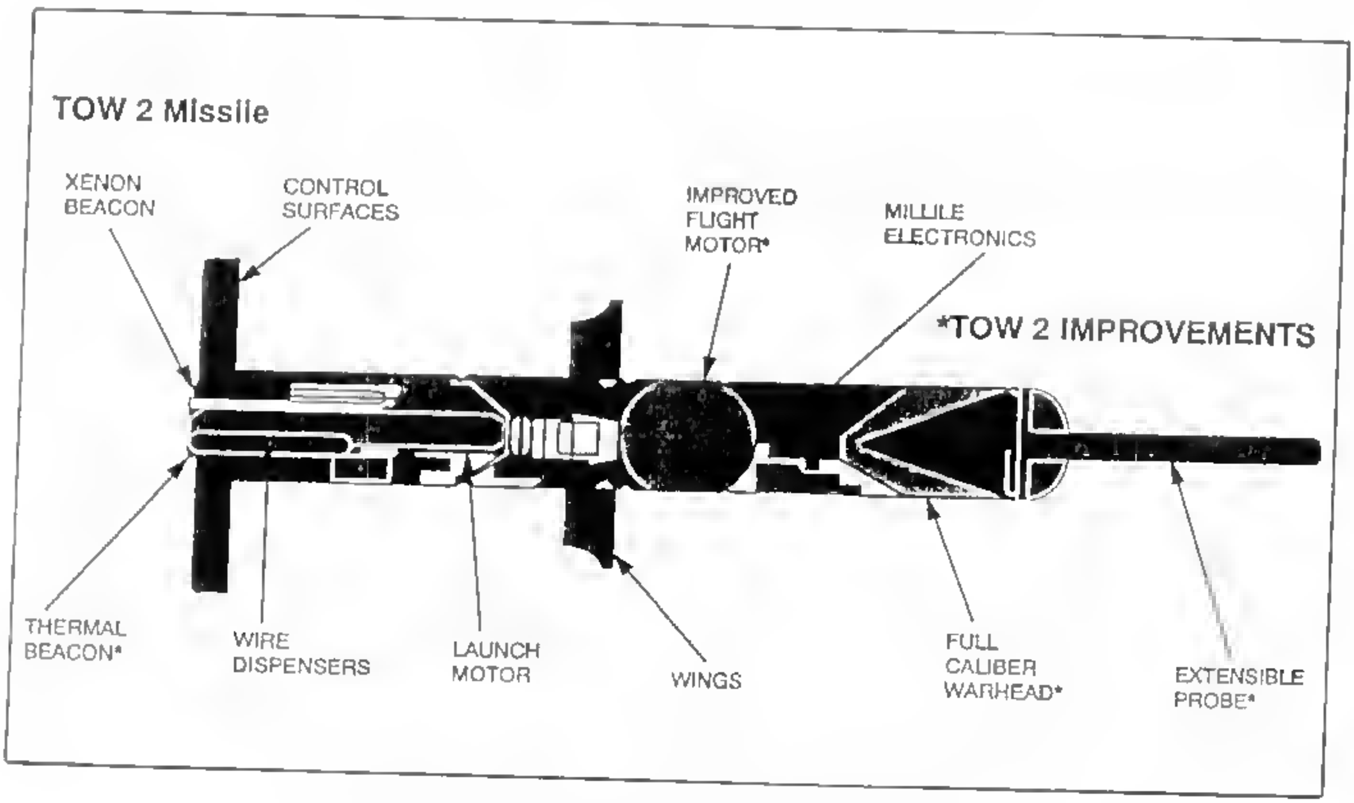


Figure 5-4. BGM-71 Series TOW Missile (Sheet 6 of 6)

Controlled infrared radiation from a source or sources mounted in the aft end of the missile provides a means of comparing the missile flightpath with the line of sight. Deviations of the missile from the intended line-of-sight flightpath are compensated for by means of correction signals transmitted from the launcher via the command link wires. These wires are dispensed during flight from bobbins mounted in the aft end of the missile.

Actuation of the onboard energy sources occur just prior to launch and continues during the postlaunch phase of flight. Prior to launch, the compressed gas source is sealed and the batteries are inactive. A prefire signal from the launcher energizes the missile batteries shortly after the trigger is pressed, but before the launch motor is energized. The batteries then supply energy to the missile electronics unit. An onboard gyroscope that provides attitude reference information to the guidance system is also energized at this time.

A fire signal then energizes the launch motor, which expels the missile from the launch tube. Upon exit of the missile from the launch tube, the extension of the missile wings actuates electrical switches. These switches initiate the remaining electrical sequences that take place during missile flight. This action includes supplying energy to puncture the actuator gas bottle seal and actuate a delay switch in the electronics unit that energizes the flight motor and the warhead safety and arming unit. The purpose of the delay is to provide safety by preventing actuation of the flight motor or warhead until the missile is at a safe distance from the launch vehicle.

The tactical missile warhead assembly includes an electromechanical safety and arming (S&A) device fitted to the aft end of the warhead. This device prevents accidental detonation of the warhead during transportation and handling. It delays delivery of the electrical energy necessary for warhead detonation for a discrete time period after the flight motor has accelerated the missile. It also controls the mechanical position of the fuze that initiates the warhead detonation sequence by keeping the fuze from the armed configuration until after flight motor acceleration. Once that acceleration (i.e., 10g's, achieved in 30 to 60 meters of travel) has been achieved and the S&A mechanism has been actuated, the only remaining step to warhead detonation is closure of an impact-sensing switch at the forward end of the warhead. Depending on the missile configuration, this switch may take the form of an ogive crush switch or a probe-and-ogive crush switch.

There are four different TOW missile tactical (BGM) configurations and three training/dummy (BTM) configurations. All have the same basic airframe, aerodynamic control system, command wire link, and forward electronics unit.

Current missiles include:

1. BGM-71A — basic tactical TOW (3,000 meter range)

2. BGM-71A-1 — basic tactical TOW with extended range (3,750 meter range)

3. BGM-71C — improved tactical TOW (i.e., ITOW) with extended range (i.e., 3,750 meters) and enhanced standoff detonation capability

4. BGM-71D — TOW 2 system with improvements that include a more powerful flight motor, a thermal beacon IR source with associated electronics, and a different forward fuselage to accommodate a 6-inch warhead (3,750 meter range)

5. BGM-71E — TOW 2A system with improvements that include a tandem warhead system to achieve increased lethality against reactive armor configurations (3,750 meter range)

6. BTM-71A-2 — basic tactical TOW with an INERT warhead that is used for flight/groundcrew training, flight carriage, and exercise firing

7. BTM-71A-2A — identical to BTM-71A-2 with launch motor case composition improvements

8. BTM-71C — basic tactical TOW with ALL INERT components that is used for groundcrew training and flight carriage ballast.

5.5.2 Launch Container. The launch container, constructed of fiber glass, provides handling/stowage protection for the enclosed missile and is also the launch tube when mated to the TOW missile launcher. Electrical initiation of the missile is facilitated by an umbilical connector on top of the container in addition to internal missile/container interface wiring. All versions of the TOW missile use the same launch container. The forward end of the launch tube is covered by a seal that is ruptured by the missile as it leaves the tube. Basic launch container color is olive drab with color bands/stripes provided forward and aft, denoting the explosive components:

1. Yellow — high explosive warhead

2. Brown — live launch/flight motor

3. Blue — INERT (practice) components.

5.5.3 Missile Sections

5.5.3.1 Warhead Section. Characteristics of the basic TOW, ITOW, TOW 2, and TOW 2A are presented in Figure 5-4.

5.5.3.2 Electronic Section. This section encircles the aft portion of the warhead and contains the appropriate solid state electronics required for internal missile component interface and control. Steering commands received from the launch aircraft via the wire command link and flight attitude references from the missile gyro are processed into command signals and distributed to the control surface actuator system located in the aft section.

5.5.3.3 Flight Motor Section. The solid base, low smoke and flame propellant flight motor is ignited after approximately 25 feet of missile flight and reaches near sonic velocity at completion of the 1.5-second burn time. Location of the flight motor near the missile center-of-gravity (cg) enhances flight characteristics by minimizing cg shift during propellant consumption. The BGM-71D and BGM-71E flight motors produce 30 percent more impulse than the BGM-71A/C flight motor to compensate for increased weight.

5.5.3.4 Center Section. This section contains the two flight motor exhaust nozzles; four fixed-position, spring-actuated folding wings, three thermal batteries, and an attitude gyro. The location of the exhaust nozzles eliminates wire command link and infrared source interference and reduces target obscuration during flight motor burning. The wings are folded into the missile case until launch tube exit when they rotate forward and lock into place assisting flight stabilization. Thermal battery activation occurs approximately 1.5 seconds prior to launch and provides power to the electronics, control surface actuators, and infrared source. The two-axis displacement gyro is activated by self-contained compressed gas when electrically initiated and provides missile flight attitude data to the electronics section to reduce crosswind effects and enhance roll stabilization. Attitude signal data is superimposed on the wire command link steering signals from the launch aircraft to ensure positive missile control.

5.5.3.5 Aft Section. The aft section has two wire bobbin dispensers containing a single-strand, high-strength, insulated wire command link that provides a 3,000 meters (BGM-71A) or 3,750 meters (BGM-71A-1, BGM-71C, BGM-71D, BGM-71E) range. A high-intensity infrared source consisting of an arc lamp, beam-forming optics, and circuitry for electronic modulation is mounted at the aft end of this section. The infrared source is modulated so that it can be distinguished from other radiation sources and possible countermeasures while enabling the aircrew to determine the missile's position in space when using the aircraft telescopic sight unit (TSU). In addition to the infrared radiator of the basic TOW and ITOW versions, TOW 2/2A has a second infrared radiator to provide hardened system performance against battlefield obscurants and countermeasures. This second radiator, called the Thermal Beacon, provides tracking link compatibility with the electro-optical infrared night vision sight.

A solid-base propellant launch motor provides initial missile flight by accelerating to 225 feet/second for approximately 25 feet where burnout occurs and flight motor ignition and burn (1.5 seconds) complete the first phase of flight. Missile final flight phase is coast down to impact. The actuator system consists of the control surface actuators and four foldable control surfaces. Extension of the folded spring-loaded control surfaces occurs immediately after launch tube exit that activates the system, releasing compressed gas from a storage bottle into the actuator manifold to drive the two-position, linear-stroke actuators. Variation in the dwell times at the end of the actuator stroke achieves the effect of smooth proportional control surface deflection. Extension of the control surfaces also electrically initiates the warhead arming cycle.

5.6 CBU-78/B CLUSTER BOMB (GATOR)

5.6.1 Description. The CBU-78/B GATOR (Figure 5-5) is a freefall dispenser/cluster mine weapon that provides the means for rapidly planting a minefield. The mines are extremely effective against armored vehicles and personnel in close-air-support (CAS) roles or interdiction missions for area denial and enemy support element harassment. The ability to preflight select a mine self-destruct time allows tactical counterattack of friendly troops in terrain previously sown with mines. The dispenser is similar to the Rockeye/APAM and is readily identified by the large stenciled GATOR on the dispenser side. The dispenser contains a total of 60 mines; 45 BLU-91/B anti-tank (AT) and 15 BLU-92/B anti-personnel (AP).

The CBU-78/B GATOR is received and loaded in an all-up-round (AUR) configuration consisting of a SUU-58/B dispenser, Mk 339 Mod 1 mechanical time fuze or a FMU-140/B dispenser proximity fuze (DPF)

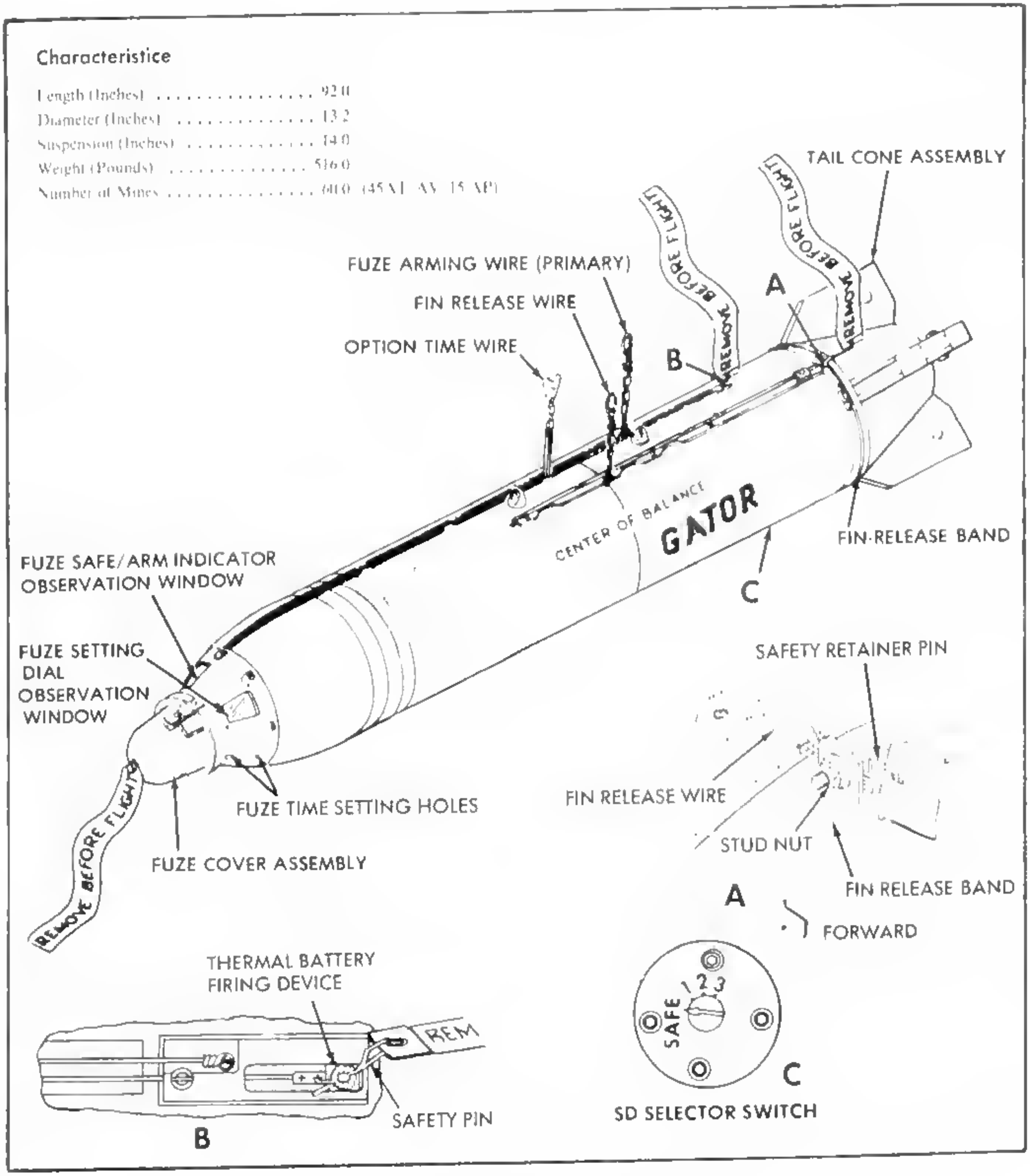


Figure 5-5. CBU-78/B GATOR Dispenser and Mine Cluster

for dispenser opening, payload of the 45 BLU-91/B AP mines, a *tether kit*, and a KMU-428/B (kit modification unit) that adapts the mines to the dispenser and provides the appropriate electrical interface for mine activation/self-destruct (SD) time selection. The *tether kit* consists of a lanyard/cable that retains the Mk 339 fuze impeller sealing band and fin release band with the dispenser at weapon release to alleviate possible aircraft damage from loose hardware. Two yellow bands located immediately behind the nose fairing denote the high explosive contents.

5.6.1.1 SUU-58/B Dispenser. The SUU-58/B dispenser is a one-piece container enclosing the mine payload that is pressurized with nitrogen to prevent mine oxidation and rusting. A linear shaped-charge, attached to the container inner wall, severs the container longitudinally when the Mk 339/FMU-140/B fuze functions, allowing the mines to dispense. With the exception of the KMU-428/B installation, the dispenser and arming wires are essentially the same as the Mk 7 Rockeye/APAM dispenser.

The Mk 339 Mod 1 mechanical time fuze is factory preset to provide an option of either 1.2 second (primary mode) or 4.0 second (option mode) functioning time. The 1.2 second functioning time is used for low altitude releases to ensure that the mines have adequate time of fall for effective dispersal pattern prior to impact. The 4.0 second functioning time is used for higher releases to delay dispenser opening, thus minimizing cross-wind effects on the free-fall dispenser and subsequently dispersed mines. To change the preset Mk 339 fuze functioning time (primary/option), use the two fuze time setting holes on the nose fairing. The fuze sealing band tether lanyard is also routed through the fuze time setting holes. In-flight selection of either primary or option mode is available.

The FMU-140/B DPF provides two in-flight selectable functioning modes, proximity (primary) and 1.2 second arm and fire (option). The proximity mode is normally used for loft/high altitude deliveries and the 1.2 second arm and fire mode is used for low altitude dive and level deliveries.

Two fuze arming wires (primary/option) are installed in conduits that are slotted at various intervals to allow positioning of the arming wire/lanyard extractor to correspond with placement of the arming units on different suspension equipment. The tail fin actuating release wire is ALWAYS POSITIVE ARMED to the suspension equipment at a designated point. Fin extension after release provides weapon stabilization until dispenser opening.

Placement of the extractor for the primary and option mode wires is labeled one dispenser for most aircraft. This placement/positioning of the extractors was determined by the aircraft suspension equipment arming unit location and circuitry. For the primary mode, *ONLY* the primary wire/lanyard is withdrawn at weapon release. To select the option mode, *BOTH* fuze arming wires/lanyards must be withdrawn. Failure to withdraw the primary wire during any normal delivery will cause the weapon to dud since it prevents the Mk 339 fuze impeller from turning and prevents the FMU-140/B thermal battery initiation. Withdrawal of the primary wire/lanyard is also required to activate the weapon thermal battery firing device (BFD) which provides the required electrical energy for mine activation and self-destruct functioning.

5.6.1.2 KMU-428/B Kit Modification Unit. The KMU-428/B physically and electrically adapts the mines to the dispenser. The kit consists of a thermal battery firing device (BFD) and battery, capacitor packs for energy storage, an event switch to trigger energy transfer, appropriate electrical assembly with interface harness, dunnage, and a self-destruct (SD) selector switch. The thermal (BFD) is located on the upper rear of the dispenser and is initiated by withdrawal of the primary fuze arming wire. The SD selector switch is located on the bottom rear of the dispenser and allows preflight selection of one of three mine self-destruct times.

Note

Failure to preselect a self-destruct time prevents arming of the mines after dispenser opening.

The three self-destruct times are:

T1 = 3.2 - 4 hours

T2 = 38.2 - 48 hours

T3 = 288. - 360 hours

Activation of the thermal battery at weapon release charges the capacitor packs. Firing of the linear-shaped charge at Mk 339 functioning, fractures a break in the events switch that triggers the transfer of energy from the capacitor packs to the individual mine lithium reserve cells. Mine arming/activation is initiated and the preflight selected self-destruct time is programmed (set) into each mine. Mine air travel/ground impact and elapsed time are required to

complete the arming/activation cycle (approximately 2 minutes).

5.6.1.3 Mk 339 Mechanical Time Fuze. The safe/armed status of the CBU-78/B GATOR can be checked by viewing the Mk 339 fuze through the nose fairing observation window. The fuze is armed if the red safe/arm indicator pin has penetrated upward into the indicator bubble through the green foil disk. The fuze function time settings can be checked by viewing the primary and option time dials through the fuze setting dial observation window. The primary dial is black and the option dial is white. Refer to the Mk 339 mechanical time fuze description for additional details. Arming requirements of the submunitions (mines) do not govern the minimum release speed required for GATOR. Minimum release speed to ensure proper Mk 339 fuze functioning is 200 KIAS.

5.6.1.4 FMU-140/B Dispenser Proximity Fuze (DPF). The SAFE/ARM status of the CBU-78 GATOR is readily apparent as protrusion of the red tipped indicator pitot tube through the radome indicates the DPF is armed. The preflight selectable ARM TIME and HOF (height-of-function) switches are located on the right side of the DPF. Refer to the FMU-140/B description for additional details. Arming requirements of the submunitions (mines) do not govern the minimum release speed required for GATOR. Minimum release speed to ensure proper FMU-140/B DPF functioning is 225 KCAS.

5.6.1.5 BLU-91/B and BLU-92/B Mines. The primary differences between the BLU-91/B and BLU-92/B mines (Figure 5-6) are the warheads and target sensor. The BLU-91/B antitank (AT) unit detonates through a magnetic sensor that detects a vehicle overpass. The BLU-92/B anti-personnel (AP) mine uses tripwires expelled from the mine for target detection and firing/detonation. Mine arming is initiated at dispenser opening when the event switch triggers the capacitor packs to charge the mine lithium reserve cells. A safe and arm (S/A) in each mine provides an out-of-line firing train until unlocked. Removal of the bore rider clip during free-fall frees the spring loaded bore rider which allows firing of an explosive actuated micro-piston (MPA), approximately 2 minutes after mine initiation (dispenser opening), and unlocks the spring loaded slider allowing alignment of the firing train. Mine detonation is initiated by either target detection, mine disturbance, premature low lithium reserve cells voltage or preset self-destruct mode. Mine dispersion after dispenser opening is accomplished by a shape adapter attached to each mine.

Characteristics	BLU-91/B	BLU-92/B
Length (Inches)	5.75	5.75
Width (Inches)	5.0	5.0
Height (Inches)	2.6	2.0
Weight (Pounds)	4.3	3.7
Explosive	RDX Esthane	Comp B
Weight (Pounds)	1.3	0.905

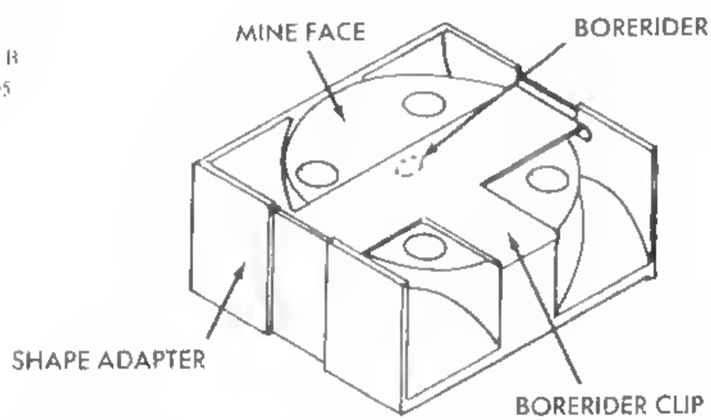


Figure 5-6. BLU-91/B Antitank (AT) and BLU-92/B Antipersonnel (AP) Mines

The BLU-91/B AT uses a bidirectional mass focus warhead designed primarily for use against tanks. The warhead contains RDX/Esthane explosive that will penetrate 2.5 inches of 300 BHJ armorplate at an 18-inch standoff. The magnetic sensor will only detonate the mine if the target passes over the mine. Elapsed time between target sensing and warhead detonation is approximately 30 milliseconds.

The BLU-92/B AP uses a fragmenting case and ground burst omnidirectional warhead with pressure sensitive tripwires sensors. The warhead contains Composition B explosive and is designed to inhibit minefield clearing efforts. The warhead has an effective P_k within a radius of 16 feet. Each mine has a total of 8 tripwires (four per face) available. Only the four from the up-face (exposed side) are deployed by a bidirectional explosive pressure cartridge and spring mechanism simultaneously with completion of mine arming. Maximum tripwire deployment length is 40 feet.

5.7 HELLFIRE MISSILE SYSTEM

5.7.1 Description. The Hellfire modular missile system (HMMS) consists of the M272 launcher, Hellfire high explosive antitank (HEAT) missile, multiple remote terminal unit (MRTU), and the remote Hellfire electronics (RHE). The missile is 64 inches long, has a wingspan of 12.8 inches, and weighs 100.8 pounds. Each missile launcher can be loaded with four Hellfire missiles mounted on the outboard pylons, giving the AH-1 the capability to carry and employ up to eight Hellfire missiles.

5.7.2 Missile Launcher. The M272 launcher is a stable structure that provides mounting, electronic control, and release of Hellfire missiles. It is configured to carry four Hellfire missiles. The launcher weighs 141 pounds empty and 541 pounds fully loaded (Figure 5-7).

The launcher also provides the wiring harnesses and electronic command signal programmer, necessary electrical/electronic switching, transfer, and control functions associated with missile prelaunch, missile sequencing, and launch commands. It has a built-in test (BIT) equipment routine that provides launcher status to the aircraft when BIT is performed by the fault detection/location systems or upon copilot initiation.

The major components of the launcher are as follows:

1. Hardback assembly — provides attaching points for the upper and lower rail supports and attaching point (lugs) for mounting the launcher to the pylon rack.

2. Launch rails — provides mounting and hold-back provisions for the missiles. A manual hold-back release facilitates uploading/downloading and when engaged, holds the missile on the rail. When missile thrust exceeds approximately 600 to 700 pounds, the hold-back is overridden, allowing the missile to leave the rail.

5.7.3 Configurations. The Hellfire missile is available in three configurations: dummy, training (laser seeker), and tactical (laser seeker).

5.7.3.1 Dummy Missile M34. The dummy missile has the same external shape and length as the tactical missile. Internally, it contains no explosives, but has ballast to simulate the weight and center of gravity of the tactical missile. It is used to train armament personnel in uploading and downloading, and also to simulate a prescribed load of missiles for a specific training flight. Dummy missiles are identified by bronze colored bands around the warhead and propulsion sections.

5.7.3.2 Training Missile M36. The training missile also has the same external shape and length as the tactical missile. Internally, it contains no explosives, but has ballast to simulate the weight and center of gravity of the tactical missile. It is used for captive flight training and cannot be launched. The missile has an operational laser seeker that can search for and lock on to laser designated targets. Training missiles are identified by blue colored bands around the warhead and propulsion sections.

5.7.3.3 Tactical Missile AGM-114B. The tactical missile contains a shaped charge warhead capable of defeating any known fielded tank. The missile arms only after launch when acceleration exceeds 10g's, somewhere between 150 and 300 meters in front of the aircraft. The maximum velocity of the missile is 475 meters per second (Mach 1.4) with an average velocity of 375 meters per second. Tactical missiles have yellow colored bands for identification (Figure 5-8).

Note

A tactical missile cannot be launched if a training missile is present on any launcher station. Tactical missiles will not be selected (powered up) if training missiles are

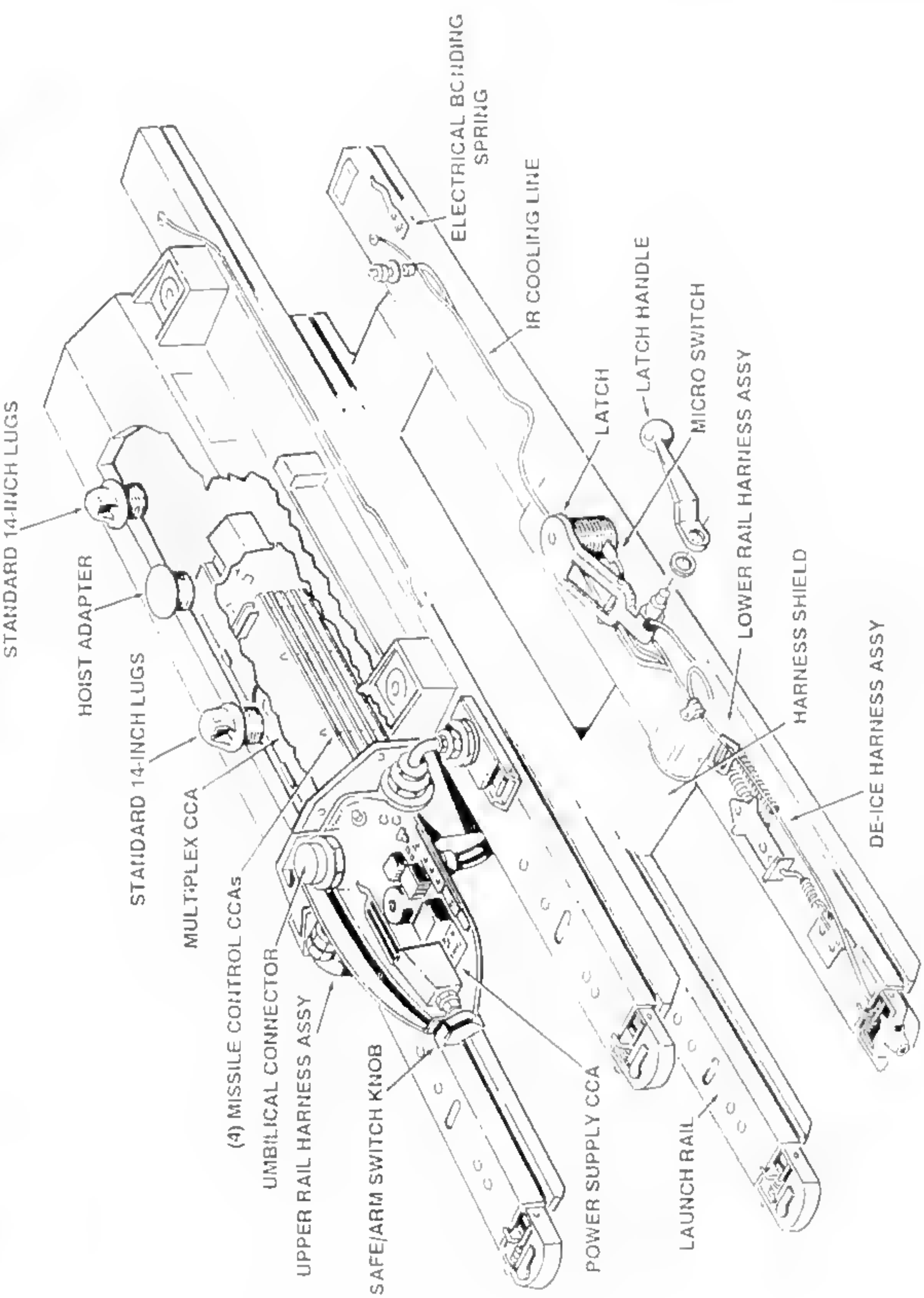


Figure 5-7. M272 Missile Launcher

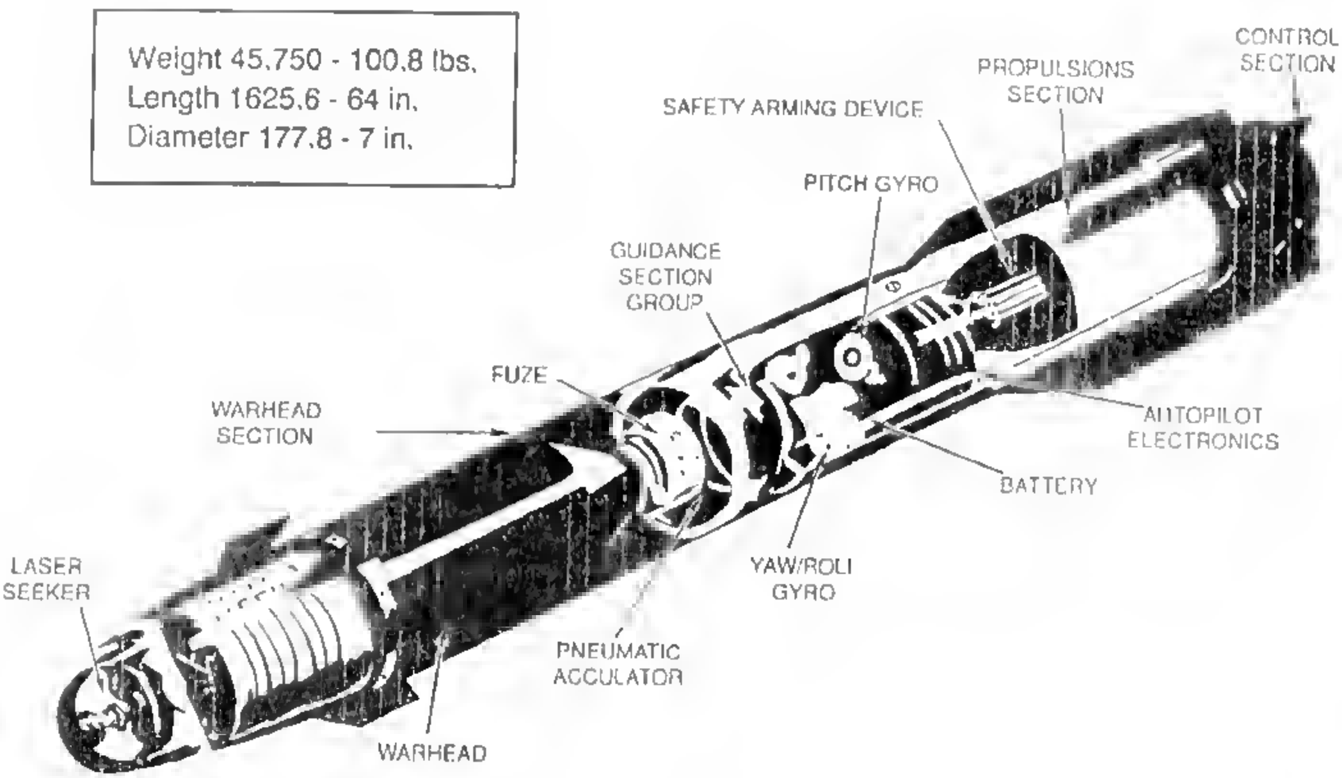


Figure 5-8. AGM-114 Hellfire Laser Homing Antitank Missile

present except during BIT. If a tactical missile launch is attempted with a training missile loaded on any launcher station, a simulated missile launch will take place. In other words, only simulated launches of a training missile will be enabled while training missiles are on an aircraft.

The tactical missile contains the following major sections:

1. Laser seeker — converts reflected laser energy from the target into electronic guidance signals.

2. Guidance section — includes missile autopilot, pneumatic accumulator, battery and displacement gyros. Computes steering command data.

3. Control section — contains a pneumatic actuation system that converts steering commands into mechanical fin movement. It is located just aft of the rocket motor.

4. Propulsion section (i.e., rocket motor) — singlestage, singlethrust, star-shaped solid propellant motor that propels the missile. Burn time is 2 to 3 seconds depending on temperature. (The rocket motor liner may burn and be visible for the duration of missile flight).

5. Warhead — uses a copper-lined biconical design shape charge to provide the explosive and piercing force necessary to destroy the target. Total weight is 22 pounds, with 13.7 pounds of LX-14 main charge (Figure 5-9).

Note

During cold weather or blowing sand conditions, a deice kit may be installed on the nose of the missile. The deice kit is made up of a frangible opaque glass dome cover and a squib-activated mechanical striker. The dome cover is shattered prior to launch.

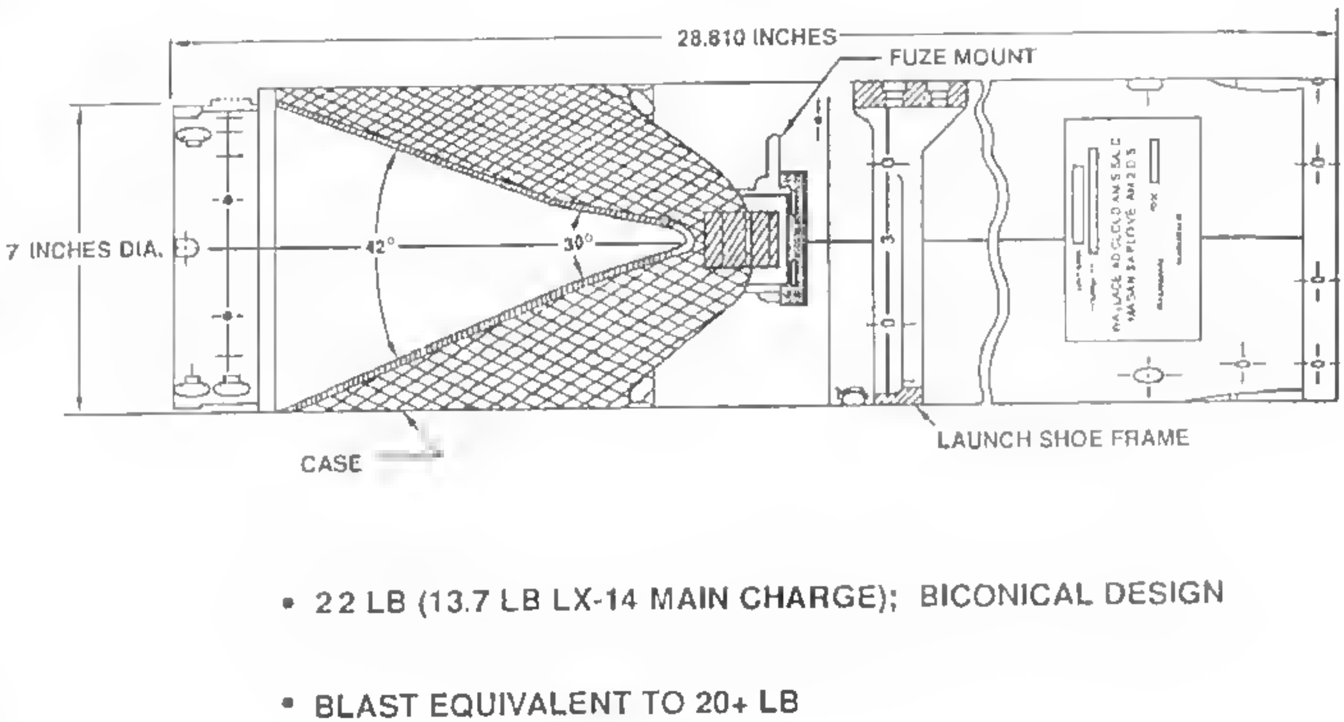


Figure 5-9. Hellfire M-265 Warhead

Three models of the Hellfire tactical missile currently exist. These models are:

1. AGM-114A — this missile is the original design Hellfire missile with the basic autopilot and low smoke rocket motor. It flies the highest trajectories of the three Hellfire missile models.

2. AGM-114B — this missile has an improved low visibility (ILV) capability; it flies lower trajectories than the AGM-114A and contains a minimum smoke rocket motor (less smoke than the AGM-114A). The AGM-114B contains a safe and arm device (SAD) electrical and mechanical blockage in the rocket motor firing train, making it approved for U.S. Navy shipboard use.

3. AGM-114C — this version possesses ILV capability; flies with the lower trajectories and contains the minimum smoke rocket motor. It flies the same lower trajectories as the AGM-114B, but does not contain the SAD.

Note

All three models are compatible with the AH-1W, although only the AGM-114B is shipboard approved.

5.7.4 Seeker. The seeker detects properly coded laser energy and provides line-of-sight (LOS) information to the missile autopilot and, while on the rail, to the RHE (Figure 5-10). The seeker detector is gimbal-mounted and gyrostabilized with a mass composed of the mirror, balance wheel, and a permanent magnet rotor, spinning at 4,200 rpm. The detector has a ±30° gimbal limit from missile centerline. The seeker has five operating modes.

1. Cage — the seeker is inhibited from slaving or tracking until the gyro mass is spun up or when the RHE commands cage.

2. Scan (or search) — the seeker is moved in a predetermined scan pattern (box scan) to help it acquire and lock on to a laser spot.

3. Stare — the seeker is commanded to look straight ahead along the missile body axis. It can acquire and lock on if laser energy is detected.

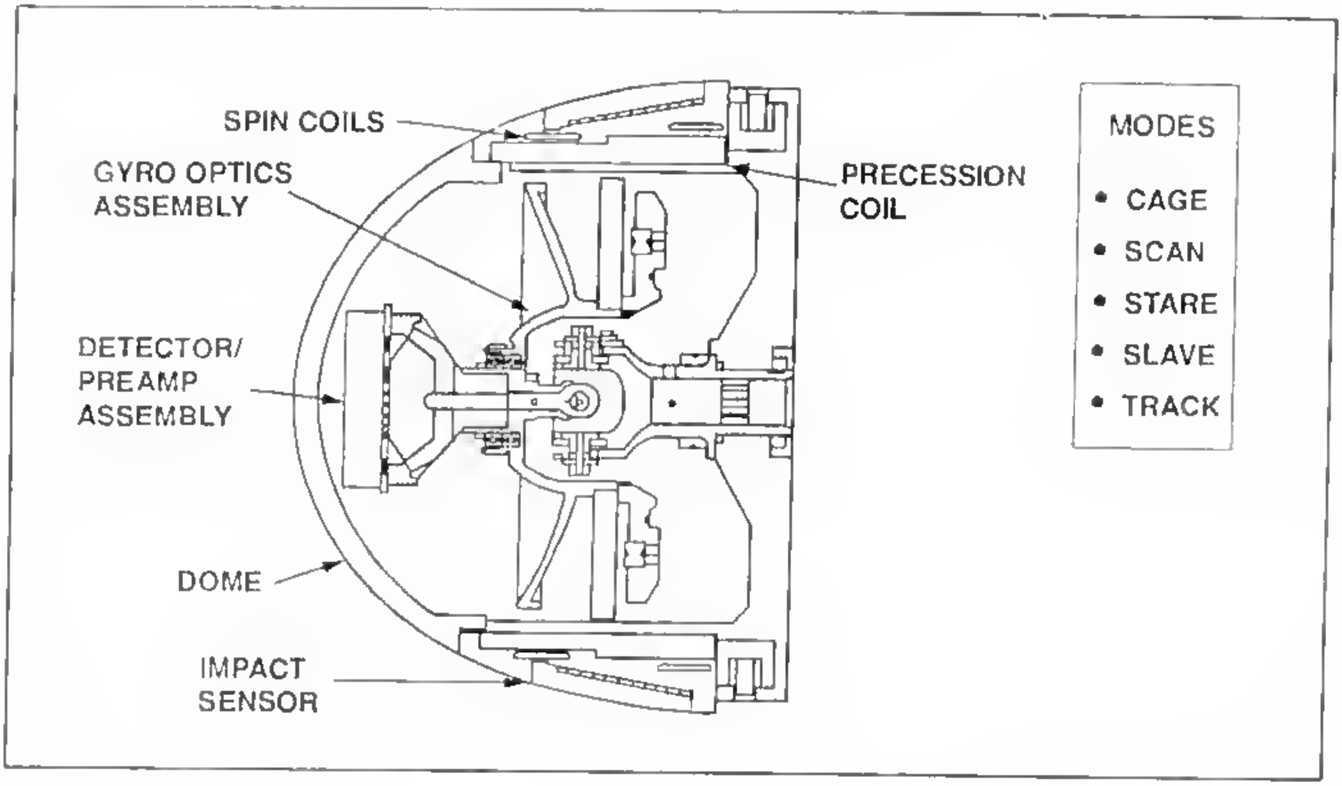


Figure 5-10. Seeker

4. Slave — the seeker is commanded in response to a line of sight (LOS) command from the missile autopilot (LOAL) or the aircraft's onboard system via the RHE (LOBL).

5. Track — the seeker is commanded by the seeker electronics assembly to maintain the reflected laser energy centered on the detector/preamplifier assembly so that the optics assembly is pointed at the target.

Note

- If in LOBL and target designation is terminated before launch while tracking a target, the seeker will revert to the slave mode.
- If in LOBL or LOAL and the target designation is terminated after launch while tracking a target, the seeker remains in the track mode and the seeker gyro becomes inertially stable thereby maintaining the last command.

In the LOBL mode, the search time limits of the seeker are as follows:

1. No time limit for continuous search operations at temperatures below 90° Fahrenheit (°F) (32.2° Celsius (°C))

2. Above 90 °F, there is a 30-minute limit for continuous search. At that time the missiles must be either deselected or placed in the LOAL mode to allow the seekers to cool. The cool-down period is 30 minutes. The rule of thumb is for every minute of continuous search in LOBL, allow an equal cool-down minute. The seekers require a 2-minute spin downtime after deselection before they are reselected.

3. There is no time limit, regardless of temperature, in the LOAL mode.

5.7.5 TOW Hellfire Control Display Panel (THCDP). The system cooling related switches on the THCDP and Hellfire pilot control panel (HPCP) are all covered in the AH-1W NATOPS and will not be addressed here.

Note

A seeker will require up to 30 seconds to spin up. Only after this time period can the missile be launched.

1. CCM/CAM switch — this switch enables the counter-countermeasures (CCM) routine within the missile.

a. This switch allows the missile to overcome suspected active electro-optical countermeasures being used within the target area.

b. The switch should be placed in the OFF position under all operational situations except when active electro-optical laser countermeasures (ECCM) are known to be deployed in the target area. When active ECCM are known to be deployed, the CCM switch should be placed in the ON position.

Note

Using the switch in the ON or TRUE position in a non-countermeasure environment could have an adverse impact on missile performance.

2. MODE switch — this three-position switch selects the mode for missile fire. The positions of the MODE switch are:

(a) Rapid position — with the launch sequence MODE switch in the rapid position and the missile system prioritized, the missile will be placed in the normal mode of operation. Only missiles coded on the designated priority channel may be launched. To launch a missile from an alternate channel, it must first be designated as the priority channel. The rapid position can be used to launch one missile or successive missiles in the rapid mode. Rapid fire is used when more than one missile is fired with a minimum delay. In rapid fire, one designator using one code is utilized. A recommended 8-second delay allows time for the laser spot to be repositioned and the subsequent missile to reacquire a different target.

(b) RIPL position — with the launch sequence MODE switch in the RIPL position and the missile system prioritized, the missile will be placed in the ripple mode of operation. As in the rapid position, only a missile on the designated priority channel may be launched. However, once the missile is launched, the RHE will automatically reprioritize the missile system, making the prior alternate channel the priority channel. This reprioritization will occur after each missile launch. With the ripple mode, more than one missile may be launched (one missile per trigger pull) on alternate missile codes. This mode is different from rapid because two designators use two separate codes.

(c) Man position — with the launch sequence MODE switch in the manual position and the missile system prioritized, the missile system will be placed in the manual mode of operation. This mode allows selection of a particular missile to be launched instead of the RHE automatically selecting the firing sequence. When prioritized, the RHE will default to the priority channel quantity selection to a quantity of one. If the missiles were previously spun up, the RHE will retain one missile spun up and encoded with the priority channel laser code, deselecting all other missiles on both the priority and alternate channels. If no missiles are spun up, the RHE will select one, encode it with the priority channel laser code, and spin it up. After each subsequent missile launch in the manual mode, the RHE will automatically select the next missile to be launched. If the missile selected by the RHE is not the missile desired for launch, a missile may be selected by using the THCDP keyboard.

CAUTION

Hellfire missile spin-down time can take up to 2 minutes. After a missile has been deselected, it should not be selected again for 2 minutes. Otherwise, the seeker assembly may be damaged.

3. The system mode switch — enables selection of the type of launch mode to be utilized. The six positions of this switch are:

(a) STBY — enables BIT and status display, allowing access to failure codes for maintenance.

(b) LO — selects the LOAL-LO mode that allows the launching aircraft to be placed behind a low mask and the missile to clear the mask during flight. The target does not have to be within the missile LOS in a LOAL-LO launch; therefore, this can be an indirect launch mode.

(c) HI — selects the LOAL mode with the higher missile flight trajectory. This mode will

allow the missile to clear a higher mask during flight if the launching aircraft is so positioned.

d. DIR — selects the LOAL mode with a direct missile flight trajectory. The term direct indicates that the target is within the missile LOS prior to launch.

e. LOBL — selects the LOBL mode. In this mode, the seeker must be locked on to the designated target prior to launch.

f. ORIDE — allows manual missile launch when outside LOBL launch constraints.

4. MSL DEICE button — the MSL DEICE button is the primary method of deice cover removal. With the MODE button on the THCDP set to LOBL, missile activated, depressing the MSL/DEICE button will remove the deice covers as follows:

a. In the LOBL mode, all ready missiles on the priority channel will have domes removed.

b. An alternate method of deice cover removal in the LOBL mode utilizes a weapon trigger pull. Since the laser seeker can not acquire laser energy through the deice dome, the RHE interprets the trigger command as a deice command and will use it to shatter the deice dome. All other functions are identical as when using the MSL DEICE button.

c. The LOAL launch deice requires no participation by the aircrew as it is completely automatic.

5. Multiple Missile Field of View — the number of missiles searching in the LOBL mode will determine the total FOV that will be covered. This FOV is controlled by the RHE and is centered on the aircraft azimuth for remote designation

a. One LOBL missile selected and searching (Figure 5-11). The instantaneous FOV of a seeker is an 8° circle/rectangle about the seeker LOS. The RHE moves the seeker LOS in a rectangular search pattern that is 6° across (±3°) and 12° vertically (±6°). By adding the instantaneous FOV to the search pattern, a total FOV of 14° across and 20° vertically is obtained.

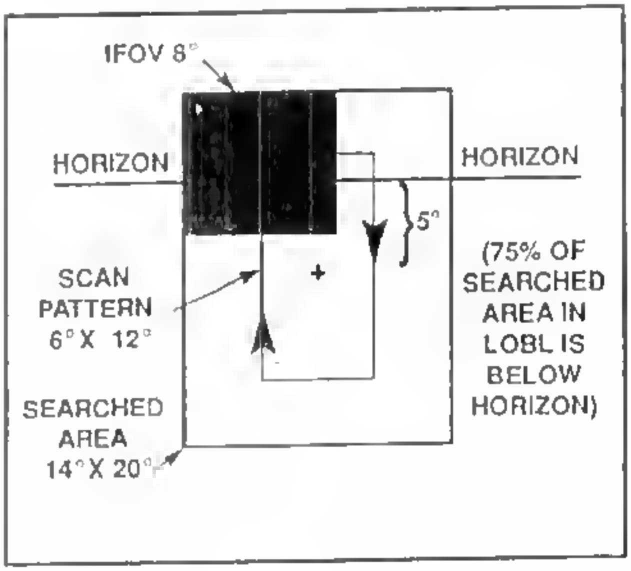
b. Two LOBL missiles selected and searching. With two missiles selected, the RHE will offset each seeker centroid 4.5° to the side of the aircraft azimuth on which the missile is carried. This gives a 9° separation between the seeker search centroids. The RHE moves both seekers' LOS in a rectangular search pattern. With the 9° offset, the two search patterns overlap each other 5° on the aircraft azimuth. The total search FOV is now 23° across and 20° vertically.

c. Three LOBL missiles selected and searching (Figure 5-12). When three seekers are selected, the RHE will command one seeker search centroid parallel to the aircraft azimuth and offset the other two; one, 9° to the right, and the other 9° to the left of the aircraft azimuth for the centroid of their search patterns. The RHE then moves all three seekers in a rectangular search pattern. Again, with the 9° offset between each seeker search centroid, the search patterns overlap by 5°, thus providing complete FOV coverage. The total search FOV is now 32° horizontally end 20° vertically (Figures 5-13, 5-14).

5.8 MAVERICK MISSILE SYSTEM

5.8.1 Description. The AGM-65E Laser Maverick missile system provides Navy/Marine Corps tactical aircraft with the capability for precision delivery of munitions against hardened land targets. The weapon system is intended to be used for close air support with the A-6E SWIP, AV-8B and F/A-18 aircraft. The AGM-65E weapon system consists of the AGM-65E missile, launcher and associated training and support equipment. The AGM-65E missile and launcher are capable of carriage, launch (missile only), and jettison (launcher plus missile) from the aircraft. The weapon system provides for destruction of hardened ground targets both during the day and at night, with sufficient standoff range to permit avoidance of terminal defenses.

The AGM-65E missile (Figure 5-15) is laser guided and rocket propelled. Guidance is provided through automatic terminal homing on coded laser energy reflecting from the target. The laser designator may be a ground device, either hand held or tripod mounted, or it may be a stabilized airborne device; either on a separate aircraft or the launching aircraft. Propulsion is provided by a solid propellant, dual thrust (boost sustain) rocket motor. The AGM-65E employs the maverick alternate warhead (MAW) with a selectable delay fuze. The missile is 97.7 inches in length, 12 inches in diameter, 28.5 inches in wing span, and 649 ±15 pounds in prelaunch weight with 145 pounds of net explosive.



- LOBL: LOCK-ON BEFORE LAUNCH
- LOBL SCAN (DOTTED LINED) IS SLAVED
- PATTERN CONTROLLED BY RHE

— C_L ** IS DEPRESSED 5° BELOW HORIZON BY RHE SO MOST OF SEARCHED AREA IS ON GROUND

— SOFTWARE COMPENSATION FOR DIFFERENT PLATFORM PYLON INCLINATIONS

— GYRO INPUT FROM AIRCRAFT ALLOWS COMPENSATION FOR FLIGHT ATTITUDES

IN ALL CASES NOMINAL SEARCHED AREA IS 5° ABOVE HORIZON AND 15° BELOW

*IFOV IS SQUARE UNDER SOME CONDITIONS AND CIRCULAR UNDER OTHERS. DUE TO OPTICAL REQUIREMENTS, PHYSICAL SHAPE OF DETECTOR IS NEITHER. NOMINAL IFOV IS 8° X 8°, ACTUAL IFOV VARIES FROM 7° TO 13°.

**C_L IS THE SEEKER-LOCK AXIS.

Figure 5-11. AGM-114B LOBL — Single Missile

The missile consists of two major sections:

1. Guidance and control section (GCS)

2. Center-aft section (CAS).

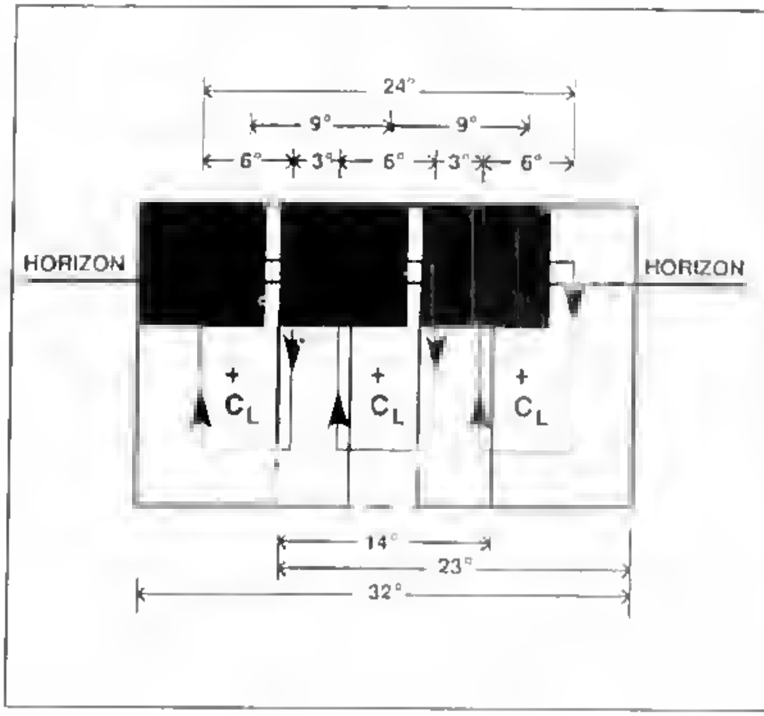
The GCS consists of the laser seeker assembly, electronics assembly, and the sensor assembly. The laser seeker assembly consists of a free gyro-stabilized platform assembly, electromechanical components, and electronics assemblies that provide for searching, detecting, and tracking reflected laser energy. The electronics assembly accepts launcher inputs, processes seeker inputs, develops seeker outputs, generates missile video and provides flight command and control signals to the hydraulic actuation system (HAS). The sensor assembly consists of rate sensors and accelerometers to develop angular rate and acceleration signals for use in the autopilot function.

The CAS consists of the main structure and wing assembly, the safety arming device (SAD), warhead (WDU-24/B, explosive blast penetrater), fuze (FMU-135/B), and rocket motor. The HAS consists of a hydraulic system which controls the flight surfaces of the missile. This allows the missile to be directed toward the target from inputs by the GCS. There are four control surfaces, one pitch-roll pair and one yaw-roll pair.

The missile interface system consists of the launcher and AGM-65E missile. Aircraft parent racks and weapons stations will vary on the aircraft utilized. The LAU-117A launcher is used to carry and launch the missile from the aircraft. The launcher is 94.5-inches long, 11.0-inches wide, 11.9-inches high, and weighs 130 pounds. The launcher holds the missile in boresight alignment during captive flight, when it is mounted on the parent rack of the pylon. The igniter arming mechanism neither arms the fuze nor ignites the rocket motor when the launcher missile assembly is jettisoned. The bomb rack is equipped with ejection capability which may be activated by the pilot to jettison the launcher (with or without the missile) downward. (The launcher is not capable of missile jettison.)

5.8.2 Description. The AGM-65F IR Maverick missile system consists of the AGM-65F IR Maverick missile, the LAU-117A(V)2/A Guided Missile

- UP TO THREE MISSILES PER CODE
- FOR ALL MISSILES LOBL ON EACH CODE RHE OFFSETS C_L'S BY 9°
- WHEN ONE MISSLE LOCKS ON, RHE AUTOMATICALLY SLAVES OTHER SEEKERS TO ALSO LOCK ON
- MAXIMUM SEARCHED AREA FOR THREE SEEKERS ON SAME CODE IN LOBL IS NOMINAL * 32° X 20°



IFOV IS SQUARE ALTHOUGH DETECTOR PHYSICAL SHAPE IS NOT (DUE TO OPTICAL REQUIREMENTS.) NOMINAL IFOV IS 8° X 8° ; ACTUAL IFOV VARIES FROM 7° TO 13°.

Figure 5-12. AGM-114 B/C LOBL Scan — Multiple Missiles

Launcher, and the associated training and support equipment. The AGM-65F weapon system is intended for use with the A-6E SWIP, AV-8B, and F/A-18 aircraft. The AGM-65F missile and launcher are capable of carriage, launch (missile only), and jettison (launcher plus missile) from the aircraft. The weapon system provides for destruction of hardened ground and water targets both during the day and at night, with sufficient standoff range to permit limited exposure to terminal defenses.

The AGM-65F missile (Figure 5-15) is an imaging infrared guided, rocket propelled, air-to-ground missile. Guidance is provided through automatic terminal homing on IR radiation from the target. The AGM-65F employs the maverick alternate warhead (MAW) with a selectable delay fuze. The missile is 97.7 inches in length, 12 inches in diameter, 28.5 inches in wing span, and weighs 649 ±15 pounds with 145 pounds of net explosive weight.

The missile consists of two major sections:

1. Guidance and control section (GCS)
2. Center-aft section (CAS).

The GCS consists of the dome, infrared seeker assembly, electronics assembly, and sensor assembly. Ship and land target algorithms are incorporated into the tracker software that are pilot selectable as the tactical situation demands. The software guidance logic optimizes the missile trajectory/aimpoint selection for certain launch conditions and for minimum missile loft.

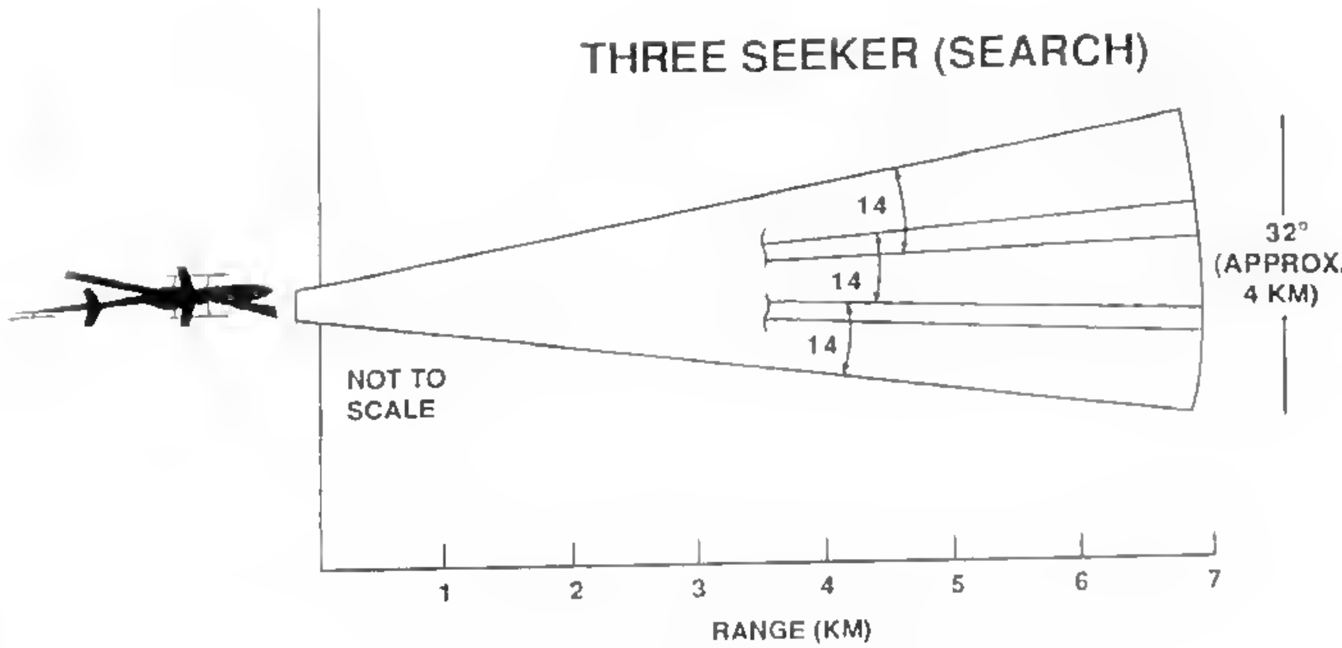


Figure 5-13. LOBL Field of View Three Seeker (Search)

The CAS consists of the main structure and wing assembly, the safety arming device (SAD), warhead, fuze, rocket motor, and the hydraulic actuation system (HAS).

The LAU-117A(V)2/A Guided Missile Launcher provides the launch platform for the AGM-65F IR Maverick. The launcher interfaces with the A-6E SWIP, AV-8B, and F/A-18 aircraft for electrical power, two-way data transfer between missile and cockpit controls and displays, and provides signals to the missile during captive carriage and for launch. The launcher also provides for missile restraint during aircraft catapult launches, arrested landings, and inadvertent missile launch.

5.9 AGM-122A (SIDEARM) MISSILE

5.9.1 Introduction. The AGM-122A (SIDEARM I) (Figure 5-16) missile is a passive anti-radiation missile designed to provide a lethal anti-radiation capability. The SIDEARM I missile and SIDEWINDER (AIM-9) are similar in appearance, but the SIDEARM is easily identified by its green paint.

5.9.2 Description. The major components of the AGM-122A system are a modified AIM-9C guidance control section (GCS), redesignated the WGU-15; a modified AIM-9L DSU-15A/B active optical target detecting device (TDD), redesignated the DSU-31/B (or DSU-31A/B); Mk 36 Mod 12 AIM-9 rocket motor; a Mk 13 Mod 2 safety-arming device; and an AIM-9L WDU-31/B warhead. The LAU-7 launcher with the ADU-299 adapter is used with the AH-1 aircraft. The AGM-122A is fired using the existing AIM-9 launch control system.

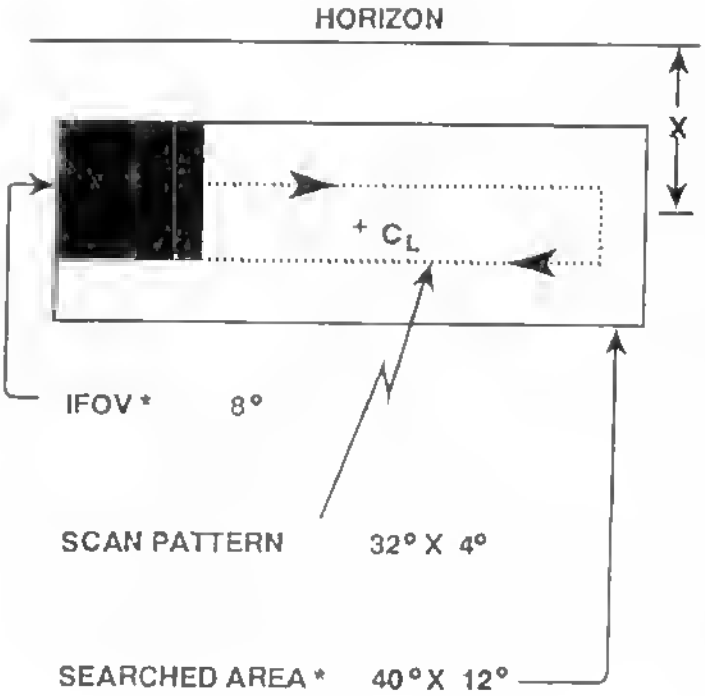
5.9.2.1 Guidance Control Section (GCS). The GCS consists of three major assemblies:

1. Passive radar seeker assembly for detecting and tracking the target

2. Electronic assembly for processing target information

3. Servo assembly with a vertical reference gyro that transforms electrical tracking signals to mechanical movement of the guidance surfaces (fins).

An umbilical cable assembly provides the electrical interface between the GCS and the aircraft launch control system. The umbilical cable is attached to the GCS by three breakaway screws that shear when the missile is launched. There are two GCSs which are identical in appearance except for identification plates and are physically and functionally interchangeable. The difference between the two GCSs is the power



- LOAL PATTERN IS CONTROLLED BY MISSILE AUTOPILOT
- PATTERN IS SHORT AND WIDE TO PREVENT FLYING PAST TARGET
- TO COMPENSATE FOR ALTITUDES OF VARIOUS LOAL TRAJECTORIES C_L IS DEPRESSED BELOW HORIZON †(X) IAW SELECTED TRAJECTORY

TRAJECTORY	C DEPRESSION
LOAL DIR	5.5°
IND LOW	11.0°
IND HIGH	13.0°

* IFOV IS SOUARE ALTHOUGH DETECTOR PHYSICAL SHAPE IS NOT (DUE TO OPTICAL REOUIREMENTS). NOMINAL IFOV IS 8° X 8° ; ACTUAL IFOV VARIES FROM 7° TO 13°

† EVEN THOUGH AGM-114 NORMAALLY FILES WITH UP TO 4° NOSE UP DURING LOAL SEARCH, C_L WILL BE BELOW HORIZON AS INDICATED.

Figure 5-14. AGM-114B/C LOAL Search Patterns

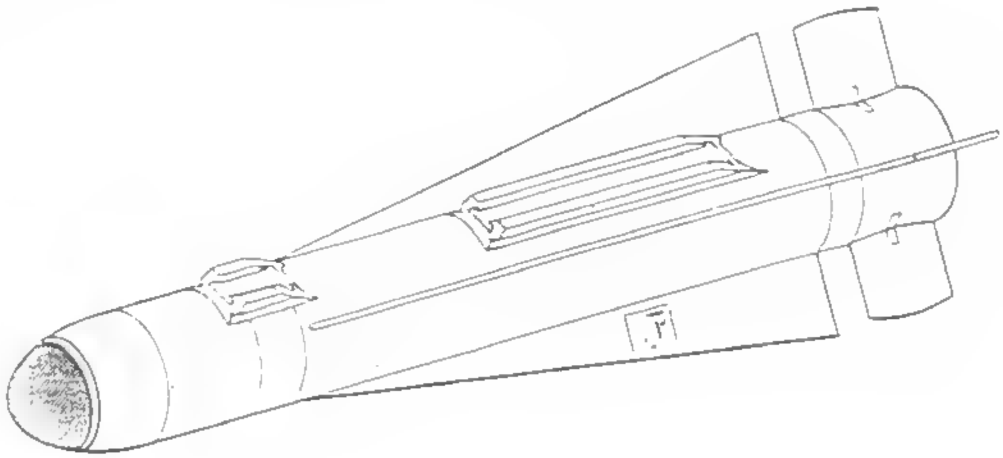
supply installed and how the power supply is internally attached.

5.9.2.2 Target Detecting Device (TDD). The TDD is a narrow beam, active optical, proximity fuze system designed to detect the presence of a target and initiate warhead detonation. Major components include:

1. A transmitter that emits four narrow fan-shaped beams through four optically transparent lenses
2. A laser receiver that detects reflected energy
3. Signal processing circuitry to initiate detonation
4. A thermal battery to provide internal power after missile launch.

5.9.2.3 Rocket Motor. The Mk 36 Mod 12 rocket motor is a single stage, short duration, solid propellant, high-thrust motor that provides an average of 2,800 pounds of thrust. This boosts the missile above the aircraft launch speed. The propellant used in the Mk 36 Mod 12 results in reduced smoke and abrasive properties. The Mk 36 Mod 12 also has a nonremovable arming key.

5.9.2.4 Safety-Arming (SA). The SA device is an electromechanical device. It is unlocked at missile launch by electrical signals from the launcher and GCS. Mechanically, it functions as an acceleration/deceleration device. The SA device maintains an out-of-line explosive train until it reacts to sustained acceleration (6g's) for a period of time/distance, which advances the mechanism into the enable position (explosive train aligned). This provides a minimum safe separation dis-



Size and Weight	
Length	97.7 inches
Diameter	12.0 inches
Stabilizer span	28.5 inches
Weight (prelaunch)	685.0 pounds
Weight (guidance unit)	105.0 pounds
Propulsion	
Type	Solid propellant dual thrust (boost-sustain) rocket motor
Guidance System	IR
Type	Biased-integral proportional navigation
Guidance head Electrical power source	Aircraft power while captive; thermal battery during launch and in free flight
Control System	
Control surfaces	Four: 1 pitch-roll pair and 1 yaw-roll pair
Servopositioners	Four hydraulic
Hydraulic power source	Compressed gas-driven free-piston hydraulic pump
Weapons Control System	Aircraft weapons control system of carrying aircraft

Figure 5-15. Maverick Missile System (Sheet 1 of 2)

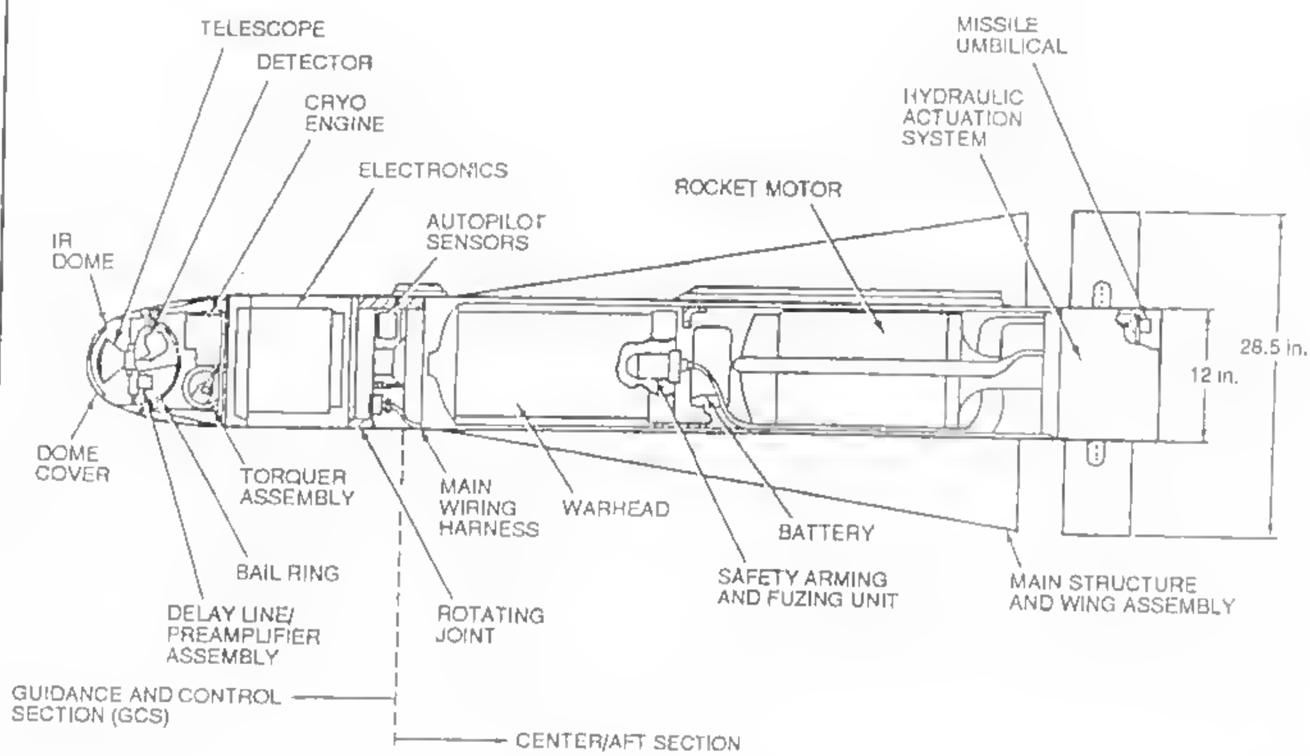


Figure 5-15. Maverick Missile System (Sheet 2 of 2)

tance between the missile and aircraft (depending upon launch airspeed, altitude), etc. Failure of the missile (motor malfunction) to obtain the sustained 6g acceleration will not align the SA device explosive train. The SA device explosive train must be aligned before the TDD or GCS can initiate detonation of the warhead. The SA device has two windows: the forward window allows viewing of the launch-latch to verify proper alignment; the aft window is for viewing the condition of the SA indicator.

5.9.2.5 Warhead. The annular blast fragmentation (ABF) warhead consists of a case assembly, booster plates, initiator, high explosive, and titanium fragmentation rods. The SA device explosive train output is transferred through the initiator, to the booster plates at each end of the warhead high explosive charge. Detonation of the explosive from both ends simultaneously results in a narrow, highly concentrated pattern of fragmentation rods that emanate in a disc-shaped pattern.

5.9.2.6 Wings. Four wings with hinged rolleron assemblies are mounted on the aft end of the motor to give the missile lift and stability. The rollerons are small gyros mounted in the 45° hinged portion of the wings and are rotated by the air stream. During captive flight, the rolleron assemblies are prevented from moving laterally by caging pins. Missile acceleration at launch uncages the assemblies. During missile flight, gyroscopic action of the spinning rolleron wheels, along with lateral movement of the assemblies, produce a force on the wings that counteracts oscillation in pitch, yaw, and roll.

5.9.2.7 Fins. Four identical, double-delta shaped, quick-attach control fins, closely aligned with the four wings, are located 90° apart on the GCS. They provide missile maneuverability, proportional to input signals from the seeker, missile velocity, and altitude. The fins, which operate in pairs, are controlled by a hot gas

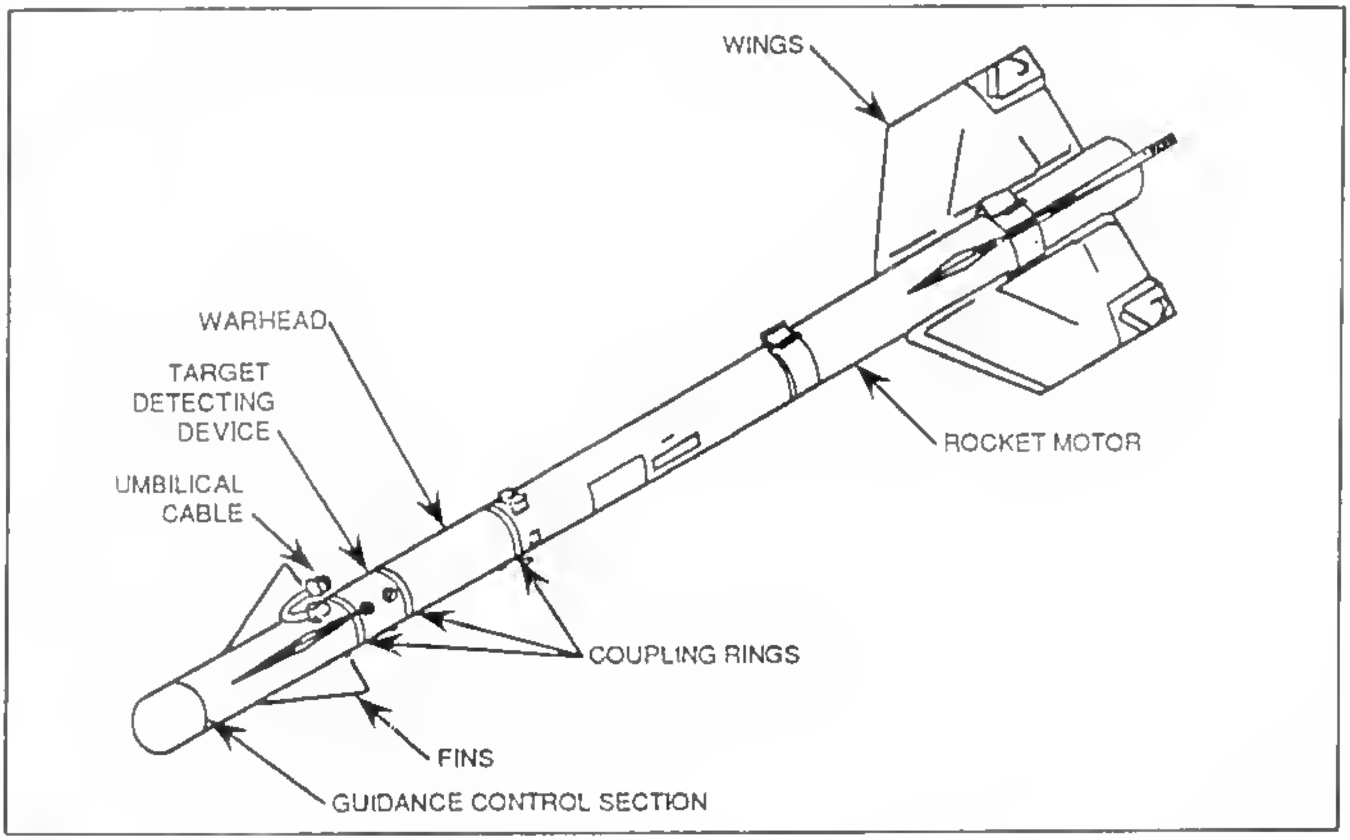


Figure 5-16. Sidearm Missile System

generator actuated servo system located in the aft section of the GCS.

5.9.3 Operation. Refer to OPTEVFOR OTG, TZ-3431-03-89, AGM-122A (SIDEARM I) MISSILE, for operation and tactical considerations.

PART II

Air-to-Air Warfare

CHAPTER 6

Weapon System Employment

6.1 GENERAL CONSIDERATIONS

The OV-10 has the capability to carry and employ a wide variety of forward firing ordnance, many of which can be used as air-to-air weapons. During air combat maneuvering these weapons can be used either defensively to confuse or deny an attacker, or offensively to destroy an enemy aircraft.

The gross weight limitations of the bomb racks and airframe determine the amount of ordnance that can be carried. The biggest limitation of the weapon system is the fixed-forward-bomb sight. The sight has no lead computing capability and is designed for air-to-ground ordnance delivery. Sight adjustments are limited to mil settings for different types of ordnance and different attack profiles.

6.2 PRECISION WEAPONS

Precision weapons carried on the OV-10 are those that are terminally guided providing a larger probability of kill (P_k) or guns used within their proper firing parameters. Accuracy of precision weapons is also dependent on aircrew proficiency and experience.

6.3 AIR-TO-AIR MISSILES

The OV-10 can carry two AIM-9 series Sidewinder air-to-air missiles. These missiles used for self protection and AAW greatly enhance the capability of the OV-10 to perform its assigned missions.

For further information concerning the techniques and parameters for using the AIM-9 series missile, refer to NWP 55-6-OV10A/D, Vol. II (NAVAIR 01-60GCB-1T(A)).

6.4 AIR-TO-AIR GUNNERY

The OV-10 is armed with 4 internal 7.62-mm machineguns and can carry up to 2 GPU-2A 20-mm gun pods. Guns can be employed against both rotary and fixed-wing adversaries; however, accurate ranges must be used to be effective. The primary targets for gun use are aircraft within effective range. The effective ranges of guns are 250 to 400 meters (roughly 800 to 1,300 feet). Air-to-air gunnery is difficult when considering that the target and the weapon's platform can both maneuver through three dimensions. A general method of aerial gunnery is to close to the minimum range, use lead aiming to miss with the first rounds, and allow the aircraft to fly through the barrage finally missing with the last rounds. This method appears counter to good weapons use, but ensures some impacts in the enemy aircraft. In other words, get close, waste bullets, and allow the enemy to fly through your tracers.

Guns will, most likely, be used against rotary wing adversaries. The gunnery method works from all aspects. If the helicopter is making a head-on pass, then attempt to fire in front of the flightpath, through the fuselage, and behind the aircraft. If at dead 6 o'clock and coaltitude, then attempt to miss above and below the aircraft with the inbetween rounds impacting. Examples of gun tracking can be seen in Figure 6-1.

6.4.1 Gun Employment Considerations. Without a lead computing gunsight, air-to-air gunnery becomes more difficult. Generally, battlesight settings should be used to fly into a position to fire and then adjust the tracers onto the target. It is imperative that aircrews practice against ground targets to get a feel for gunfire trajectory and against aerial targets to adjust tracers onto the target. Because of the limited number of rounds, accuracy is extremely important. Mil settings for air-to-air gunnery are dependent on weapon type, g loading, and airspeed. Straight and level mil settings against a nonmaneuvering target are between 33 to 57 mils dependent on airspeed and weapon (7.62 or 20 mm). Against a maneuvering target the settings are between 40 to 90 mils. A good battlesight setting for air-to-air targets is 50 to 55 mils.

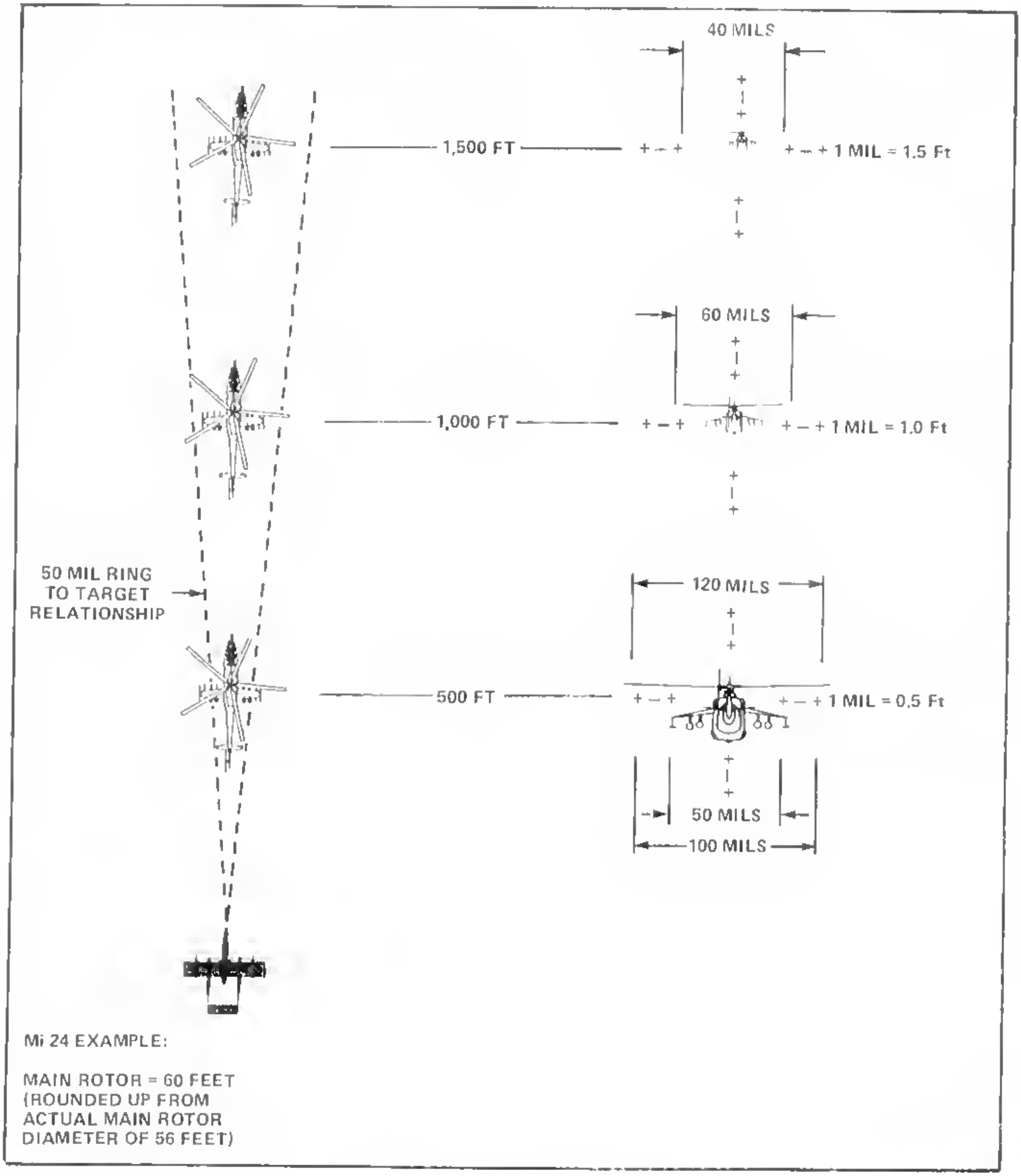


Figure 6-1. Gunsight Picture (Sheet 1 of 2)

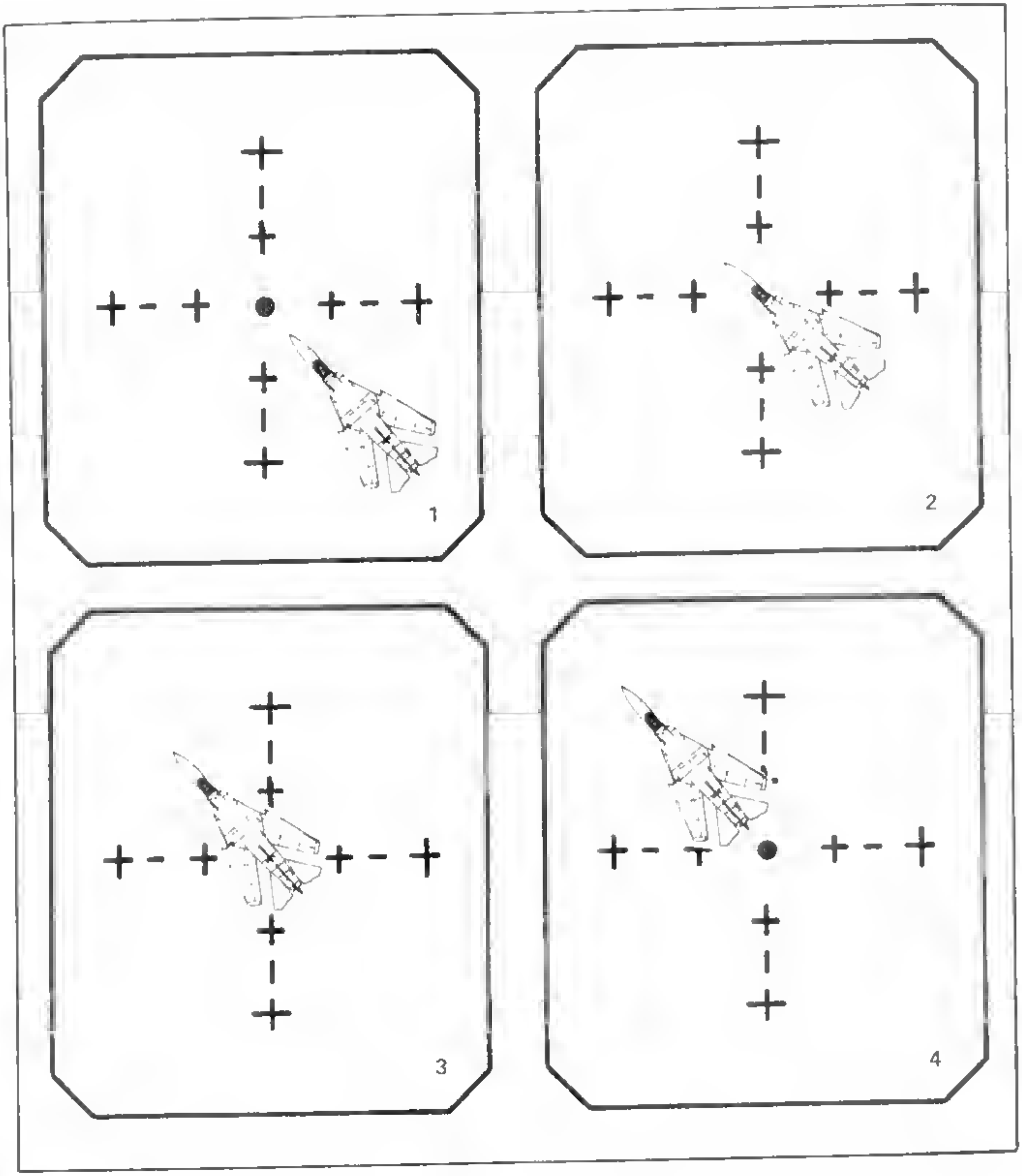


Figure 6-1. Gunsight Picture (Sheet 2 of 2)

6.5 AIR-TO-AIR GUNNERY TRAINING

Aircrew may conduct firing exercises on towed targets to increase their combat readiness. The following describes the banner and dart gunnery patterns and procedures for conducting firing exercises.

6.5.1 Banner Gunnery Pattern. The gun firing exercise using the aerial banner should be conducted 1,500 to 5,000 feet above ground level (Figure 6-2). The following procedures are recommended for a two-plane pattern. (For a four-plane pattern the interval is half the two-plane time.)

1. The tow aircraft and escort establish an orbit at the rendevous point. When the flight leader has the tow aircraft in sight, the escort may detach and join the firing group in a trail position (2,000-foot section, 1,000 feet division). With a 2,000-foot altitude advantage, the flight leader will vary AOB to arrive perpendicular to the tow aircraft flightpath being 2,000 feet in front and 4,000 feet abeam. The tow driver will transmit directions for the spacer pass (i.e., "SHOOTERS, THIS WILL BE A SPACER PASS, PASS LEFT, PERCH RIGHT, COLD RANGE"). Flight lead will acknowledge.

2. Lead will continue forward to arrive at a position directly over and perpendicular to the banner with other shooters in trail. Approaching the banner, the flight leader calls in on the spacer pass announcing fly by and perch side with respect to tow (i.e., "LEAD'S IN, SPACER, PASS LEFT, PERCH RIGHT"). Each succeeding aircraft calls in repeating spacing and perching instructions with 12 seconds of separation on roll in. Each flight member adjusts power to MRT on roll in and descends to achieve firing speed of 250 KIAS. Trim should be adjusted to hands-off flight at firing airspeed.

3. Fly by the tow 50 feet above and close abeam (100 to 150 feet) with wings level. When abeam the tow, transmit "(CALLSIGN), OFF, SWITCHES SAFE." The tow driver should state the spacer pass time (30 to 40 seconds). Start timing passing the tow for 6 to 8 seconds then execute the turn to high reversal. Smoothly but smartly raise the nose 15° nose high and stop it. Roll to 45° AOB and 1.5g and fly across the flightpath of the tow.

4. Hold the turn until passing the 11 or 1 o'clock position of the tow. (The tow will appear on the inside of the turn just below the sponson.) Reduce the AOB to 15° to 25° and nose attitude to 6° to 8° nose up. Fly out the bearing line to the high reversal. The high reversal is 900 feet above, 3,000 feet abeam, and 20° to 25° in front of the tow. Reverse the turn to 45° AOB and climb at 150 KIAS to the perch. The perch is 1,000 feet abeam and 2,000 feet above the tow and parallel. It is essential to maintain at least 150 KIAS on the perch or you will become sucked in the pattern. After the tow has called the pattern "HOT" and the area ahead is clear, the guns can be switched to READY or FIRE on the firing panels. MASTER ARM will only be turned on when tracking the banner.

5. Roll in from the perch only if all aircraft are in sight and your opposite has called "OFF." Transmit "(CALLSIGN), IN" and roll in off the perch. Overbank to achieve 80° to 90° AOB with the nose dropping below the tow and 1.5g. Pulling the nose toward the banner, fly to the low reversal point. The low reversal is 1,200 feet above and 2,000 to 2,500 feet abeam the banner. At the low reversal, rapidly reverse directions to hold the pipper approximately 100 feet in front of the banner.

6. Track the banner smoothly before firing. Commence firing at the desired firing range. There will be approximately 3 seconds of firing time to the minimum range of 800 feet. Use 1-second bursts to fire. Using 45 to 55 mils, attempt to commence firing with the pipper in front of the banner and allow the banner to be pulled through the tracers. Identify pattern errors early in the tracking run or corrections cannot be made.

7. Cease firing when:

   (a) At 800 feet range;

   (b) The banner is getting square as opposed to rectangular in appearance; or

   (c) The banner is one banner width above the horizon. (The attack should be made looking down on the banner.)

Note

Break away immediately if a square banner is seen.

After firing, keep the g on the aircraft and reduce AOB to roll wings level and pass above and behind the banner. Never pass below the banner. After passing the banner, turn to parallel the tow flightpath and pass by as on the initial spacer pass. MASTER ARM should be turned off. When abeam

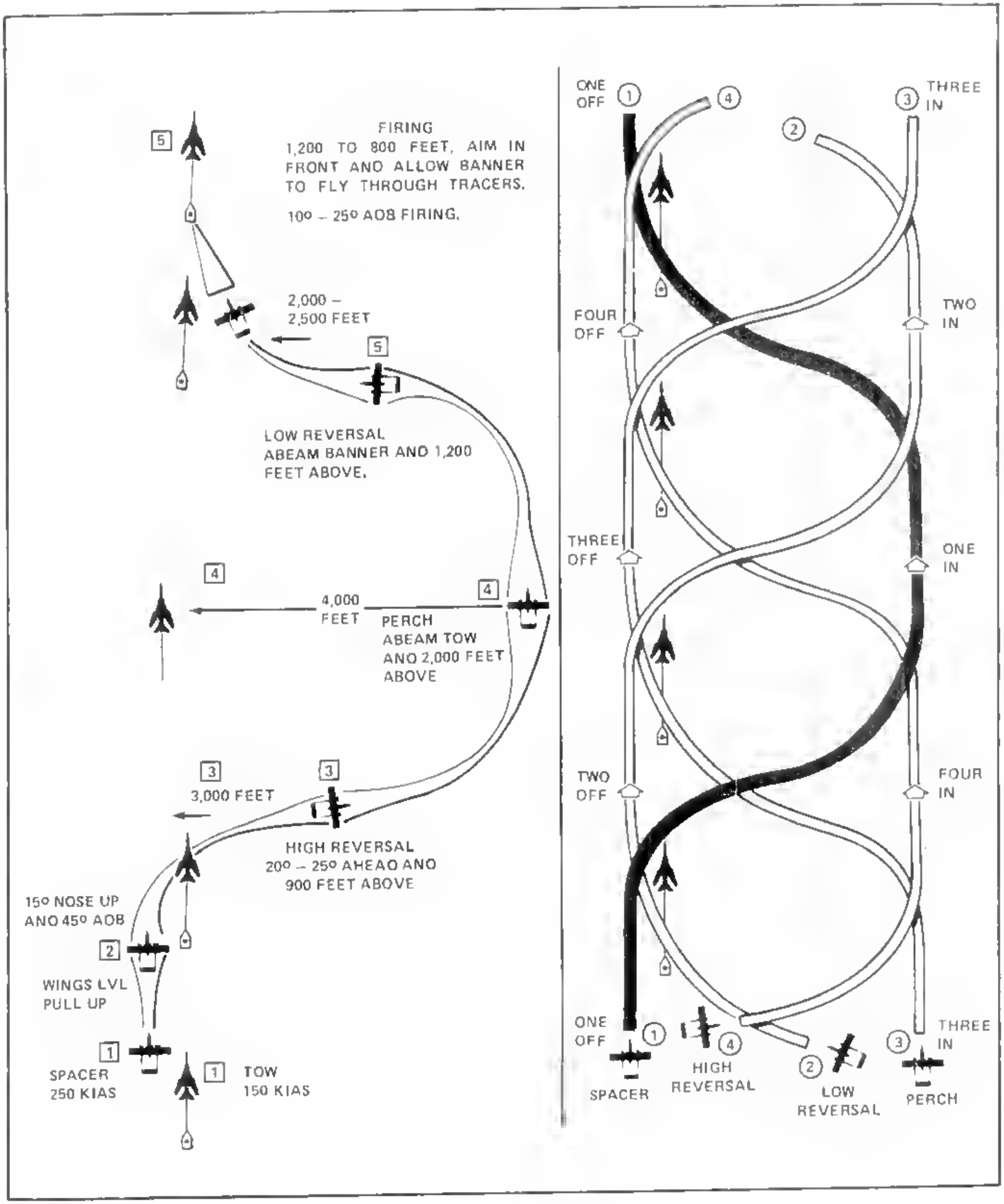


Figure 6-2. Banner Gunnery Pattern

of the tow, transmit "(CALLSIGN), OFF, SWITCHES SAFE," and commence timing for the turn to high reversal.

The pattern continues until reaching the end of the range. If the pilot loses sight of the banner or other aircraft at any time in the pattern, he should call immediately and follow the instructions of the tow driver or break off the run and try for the next pass.

8. At the turnaround end of the range, the tow driver should notify the lead that the end of the range is approaching by transmitting "LEAD, MAKE THIS YOUR LAST RUN." Lead then calls, "(CALLSIGN) IN, LAST RUN THIS HEADING." After the last run, lead will transmit going past the tow, "LEAD'S OFF, PERCH RENDEZVOUS" and time 12 seconds to turn toward the high reversal. Lead will turn to parallel the tow 2,000 feet above the abeam. Each succeeding aircraft will call off and follow lead to assume a trail position like the initial spacer pass.

WARNING

Ensure that the MASTER ARM switch is in the OFF position when in trail.

When the last aircraft calls off, the flight lead instructs the tow to turn and proceed back down range. Flight lead attempts to set the flight in a position perpendicular to the tow as in the initial spacer pass and then proceeds in the same manner as before.

Note

Before leaving the range on the final run, safety the guns by clearing them first and then turning firing switches off and MASER ARM off.

6.5.2 Communications. Two-way radio communication is mandatory for entry into the gunnery pattern. If a radio failure occurs in the pattern, rock the wings on the perch and come in for a normal cold run. Join on the pattern side of the tow and he will inform the rest of the flight. Do not cross under the tow. If he wants to change sides, he will pass the lead and do a crossunder on the NORDO aircraft. Stay joined to the tow until given the break off signal, then detach and join with a flight member of RIB. If the tow is NORDO, he will rock his wings until the shooters rendevous and will then join with the escort to drop the banner in the designated area.

6.5.3 Emergencies. If an emergency is experienced at any time in the flight, advise flight lead of the situation. If immediate return to base is necessary, a member of the flight will be detached to escort. If the emergency is runaway guns, keep the aircraft pointed away from the pattern and toward the ground if possible.

6.6 NONPRECISION WEAPONS

The term nonprecision is used in reference to air-to-air weapons. It is also used to mean unguided and having a very low P_k. The weapons discussed in this section have, basically, no capabilities against jet aircraft and just slightly increased capabilities against helicopters. Nonprecision weapons include the rockets, both 5-inch (Zuni) and 2.75-inch, that can be fitted with a wide variety of warheads. Specific types of warheads and their descriptions can be found in Chapter 4. (Guns can also be considered nonprecision weapons if fired from outside the effective ranges.) These weapons were designed for air-to-ground use and the accuracy will be dependent on the experience of the aircrew.

6.7 ROCKETS

Employment of rockets against helicopters is based on sight picture, slant range, and weapons accuracy. Without a lead computing gunsight, the amount of lead to use must be interpolated by estimating enemy aircraft speed and multiplying by .6 meters or 2 feet (i.e., for every 100 KIAS, 60 meters or 200 feet of lead should be taken). This computation is only rough estimation. Mil setting for air-to-ground targets is 50 to 60 mils (2.75-inch rockets) and 55 to 65 mils (5-inch rockets) when using dive angles of 5° to 20°. (A battlesight setting of 55 to 60 mils is acceptable.)

Use of a long, shallow dive will provide a longer tracking time and better range determination, but there will be increased longitudinal error of the impacts. Short, steep attacks provide more accuracy, but less tracking time. Long shallow attacks provide for both rocket and gun employment on a single run making it a better attack method.

The effective ranges for rocket use against helicopters is 800 to 1,600 meters. A target such as a Hind which is 17 meters long would be approximately 10 mils at maximum range and 20 mils at minimum range. Sight picture with lead interpolation for a rocket attack would be similar to that in Figure 6-3.

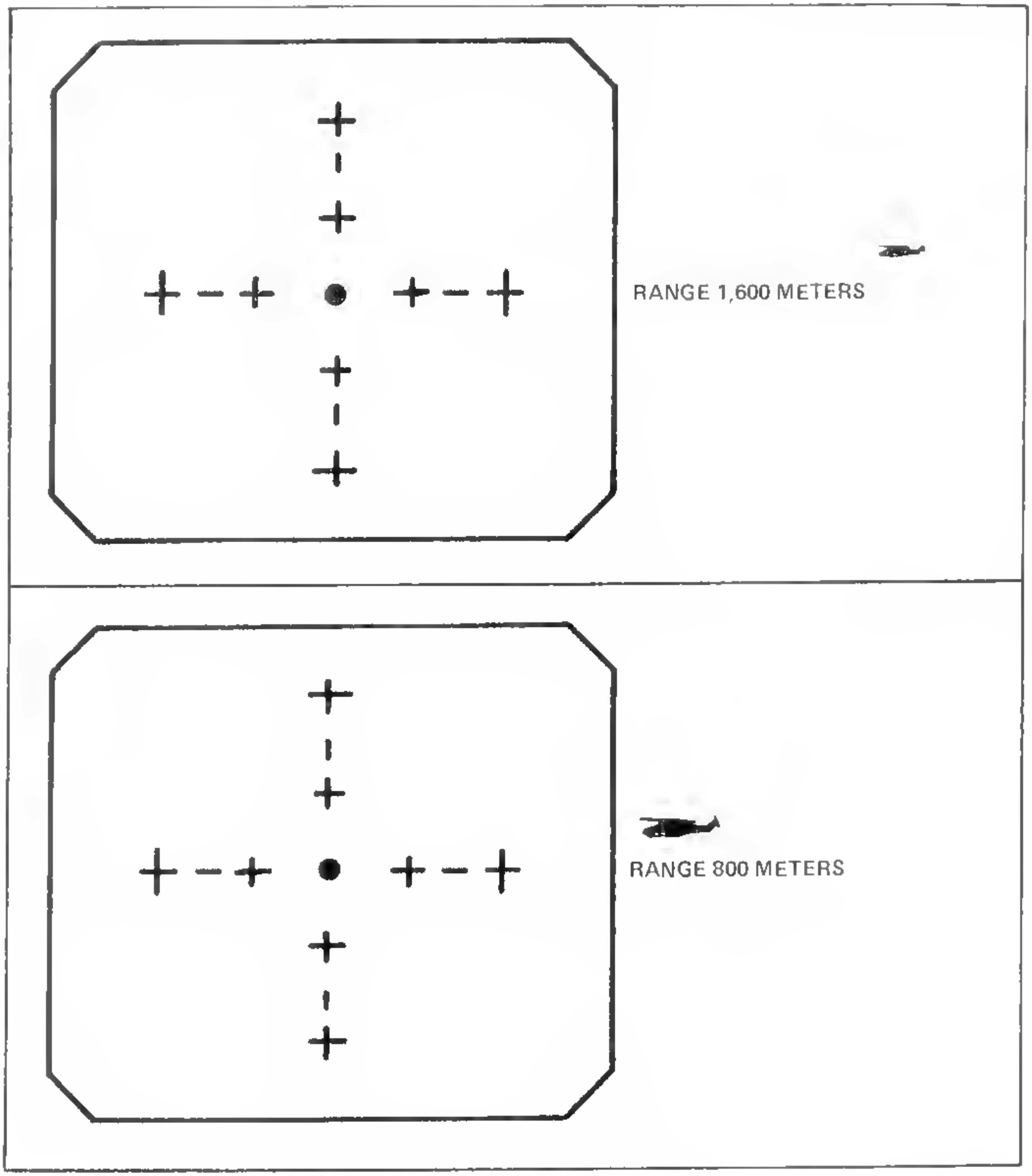


Figure 6-3. Rocket Firing Sight Picture

Unguided rockets are not usable against fixed-wing aircraft because of their inaccuracy. It is possible to shoot a barrage of 2.75-inch rockets at a jet to attempt to thwart an attack. It is more likely that a 5-inch rocket can be used as a decoy against a jet. A 5-inch rocket can be perceived and resembles an air-to-air missile. If it is to be used as a deception, it must be fired from a position that ensures that the enemy pilot will see it and, hopefully, take evasive action. The OV-10 aircrew should use the time the enemy is decoyed to disengage or get assistance from other antiair sources. When firing from an abeam position, ensure that proper lead is taken to appear as a tracking missile.

6.7.1 Rocket Employment Considerations. Combat loads need to have warhead types that are effective against helicopters. Warheads that can be effective are high explosive (HE) fragmentation, HE with variable time fuse (VT) fragmentation, and white phosphorous (WP). Though it is possible that a rocket might hit and destroy a helicopter, only fragmentation damage is considered here. The normal fragmentation pattern for an impact fuse can be found in NWP 55-6-OV10A/D, Volume I.1. Roughly, 2.75-inch fragmentation patterns are 1,000 feet in range and altitude and 5-inch patterns are 2,000 feet in range and altitude. Fragmentation damage can be inflicted on helicopters inside this pattern.

Consideration should also be given to protective armor location on helicopters. Like other aircraft, the engine components and aircrew are armor protected. The rest of the aircraft is subject to fragment damage. A properly placed rocket, especially 5-inch HE, can cause significant damage to a helicopter. Proper placement of rockets is depicted in Figure 6-4 and should provide the most effective fragmentation pattern against the helicopter. As a general rule, attempt to place the rockets 100 meters in front and slightly offset from the flightpath. If a helicopter is flying NOE, blast can also be effective, but impacts must be closer. After engagement with rockets, the OV-10 can continue to close to a gun attack.

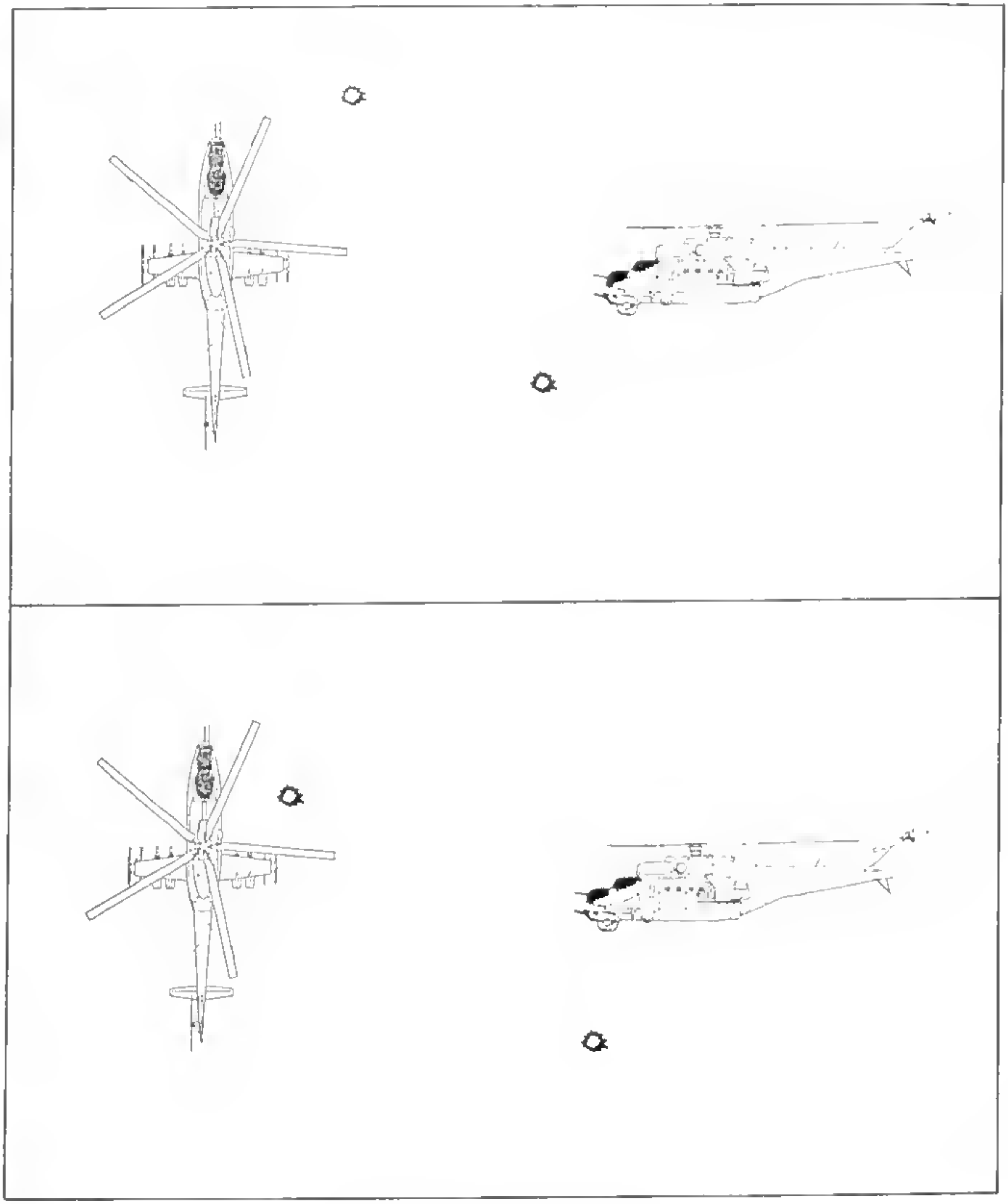


Figure 6-4. Rocket Placement

CHAPTER 7

Air Combat Tactics

7.1 GENERAL CONSIDERATIONS

The OV-10 aircrew is a key element in integrating airstrikes and artillery with the ground commander's scheme of maneuver and, consequently, is a prime target for enemy strike and fighter aircraft. OV-10 pilots and observers must therefore be trained to perform their mission and survive in areas where enemy aircraft pose a threat.

The following discussion of OV-10 defensive tactics is general in nature and is based on equipment presently available. In particular tactical situations, the best defensive maneuver may be one that is not mentioned here. Rapid advances in offensive and defensive air-to-air systems technology will certainly provide the OV-10A/D with new options, but will also change the nature of the threat. As a result, defensive tactics must be constantly reevaluated as new tactical contingencies arise. This discussion is based on the following principles:

1. The OV-10 tactics must incorporate the most effective methods to ensure quick acquisition of enemy aircraft and to permit rapid transition to the best possible defensive posture.

2. After initial defensive maneuvering, the primary goal of the OV-10 aircrew is to disengage, so that they may continue their primary mission.

3. Offensive maneuvering is both a viable defensive tactic and, in the performance of certain missions, a necessary offensive tactic to cause the disengagement or destruction (by missile fire) of an attacking enemy aircraft.

7.1.1 Aircraft Vulnerability. To effectively acquire and disengage from an enemy air threat, the OV-10 pilot must have a thorough understanding of the vulnerabilities of his own aircraft. The primary vulnerabilities of the aircraft are in the areas of infrared signature, aircraft silhouette, and rearward vision.

7.1.1.1 Infrared Signature. The infrared signature of the OV-10, while significantly less than most combat aircraft, is still a vulnerability factor due primarily to the engine exhaust. A fighter aircraft approaching from low at 5 to 7 o'clock, armed with infrared seeking missiles, may have a tone from maximum to minimum firing range. An aircraft attacking from low at 3 or 9 o'clock will usually obtain a tone just prior to minimum range, but a shot is still possible. Maneuvering to block the engine exhaust from the line of sight of the attacking fighter will significantly reduce the infrared signature of the OV-10.

7.1.1.2 Aircraft Silhouette. An understanding of the effects of the aircraft's silhouette is important when under attack by aircraft cannon. Aircraft cannon fire is generally effective from any quadrant, but the OV-10 presents a much larger target in the *plan-view* than it does head on. While a 90° track crossing angle is sufficient for a defending jet to spoil the gun or missile shot of an attacking fighter, it is not sufficient for the OV-10. Because of the OV-10's slow relative speed and larger *plan-view* silhouette, the gun attack of the fighter will not be hindered by this angle-off maneuver. Therefore, as the fighter approaches gun firing range, pull hard *off* of the 90° track crossing angle to meet him. This maneuver should both present him with a smaller silhouette and upset his gun tracking solution.

7.1.1.3 Rearward Visibility. The areas blocked by the engine nacelles and tailbooms (4 to 8 o'clock) are vulnerable areas from which an attack is most probable. These areas must be cleared frequently throughout the conduct of a mission. A slow and easy S-turn maneuver of 20° to 30° angle of bank and 20° off the base heading is the best method to accomplish this clearing requirement.

7.1.2 Operating Altitudes. The operating altitude of the OV-10 directly affects its degree of vulnerability because it largely determines what air-to-air weapon systems can be directed against it. Above 1,500 feet in flat terrain, it presents a good radar target, and ground-controlled intercept (GCI) radar may be used to vector fighter aircraft into the optimum position for attack. The attacking fighter aircraft's onboard radar can then be used to obtain a lock-on for the missile(s) carried, whether infrared-seeking or radar-guided (all weather).

Low-altitude flight significantly degrades several of these enemy air-to-air attack capabilities. In most cases, GCI radar will not be able to maintain an effective lock-on. In this case, enemy fighters must locate the OV-10 visually or with radar, then maneuver into position for the attack. Unless the fighter can achieve a look-up position with a sky background, infrared-seeking missiles will not be reliable, because of infrared emissions of terrain and vegetation. Radar-guided missiles are similarly limited at low altitudes because of spurious radar reflections.

WARNING

Attack by aircraft cannon is not degraded by low-altitude flight. The attacking pilot may even be assisted if the OV-10 neglects lookout doctrine, because of the increased concentration necessary when involved in low-altitude flight.

Flight at low altitude may result in greater vulnerability to surface threats such as AAA and small arms fire. The aircrew must constantly evaluate the air and surface threats to determine what altitude is best suited to completion of the mission.

7.1.3 Lookout Doctrine. The most critical and difficult aspect of defending against enemy aircraft is the initial visual acquisition. Aircrews must be skilled in visual search techniques, object recognition, and map reading (determination of enemy's exact location). Flight leaders should assign each aircraft a sector of lookout responsibility. (Each pilot should then do the same in his aircraft.) Within the limitations of aircraft configuration, the sum of the covered sectors should equal 360° in both horizontal and vertical planes. The second aircrew in each aircraft should provide additional overlapping sectors. Generally, the rear aircrew looks in the opposite direction as the pilot. Clock positions should be reviewed by each aircrew as soon after man up as possible. Lookout techniques must be practiced to become habitual.

Except when traversing channelizing terrain, the combat spread and combat cruise formations (Figure 7-1) greatly assist in acquiring and defending against attacking aircraft. (Combat cruise is similar to spread except the wingman is free to maneuver from 0° to 45° from lead's wingline.) The mutual support provided by these formations displaces the mutual blind area outside of most air-to-air weapons. An example of section lookout responsibilities is shown in Figure 7-1.

The most effective scan rate during individual search is 20° per second. Visual detection will depend on such factors as atmospheric conditions, aspect, background, and aircraft size. A general rule of search is to scan out to 5 miles. This is done by focusing on a point on the ground 5 miles away, then using a scan pattern at that focal length. Range focus should be checked about every 20 seconds or after each cockpit check. The depth of field will actually be from 1 mile to infinity. The scan pattern should be established that focuses on the terrain and air. One possible pattern is to use a figure eight pattern that covers 180° of vertical and 30° of horizontal area in about 15 seconds. This technique should provide for acquisition of low helicopters at 1.5 to 3 miles, low flying jets at 2 to 4 miles, and medium altitude jets at 3 to 6 miles.

Individual aircraft search sectors should be in effect from takeoff to landing. These practices should provide the earliest possible detection of attacking aircraft in all quadrants. Lookout techniques and responsibilities should be established during the planning phase of flight considering terrain, threat aircraft, likely avenues of approach, and areas of most probable contact.

7.2 AIR COMBAT TACTICS

Adherence to the principles of air combat is important; however, flexibility in their application is also important. Absolutes in air combat are few. No two situations will be alike and the enemy will probably not act predictably in a given situation. Successful aircrews will be those that can grasp the total situation, maneuver instinctively, and maintain good C3. Specific tactics for a specific situation are not possible and vary with aircrew. It is important to remember that recommended tactics are not absolutes because of to the numerous combat possibilities. To succeed, aircrews must be continuously and instantly adaptable.

7.2.1 Tactical Considerations. Aviation unit commanders and aircrews should be continually aware of factors that influence air combat tactics and decisions to engage or avoid the enemy. Some of these factors are:

1. Mission — if the mission is antiair warfare, then the force employment and ROE will be directed by higher authority. If enemy contact is possible on other missions, aircrew will make the decisions concerning engagements.

2. Friendly situation — the missions of higher, supporting, support, and adjacent units will affect air combat tactics (i.e., the availability of AIM-9 missiles is dependent on the need of the other units). The status and capability of other aviation

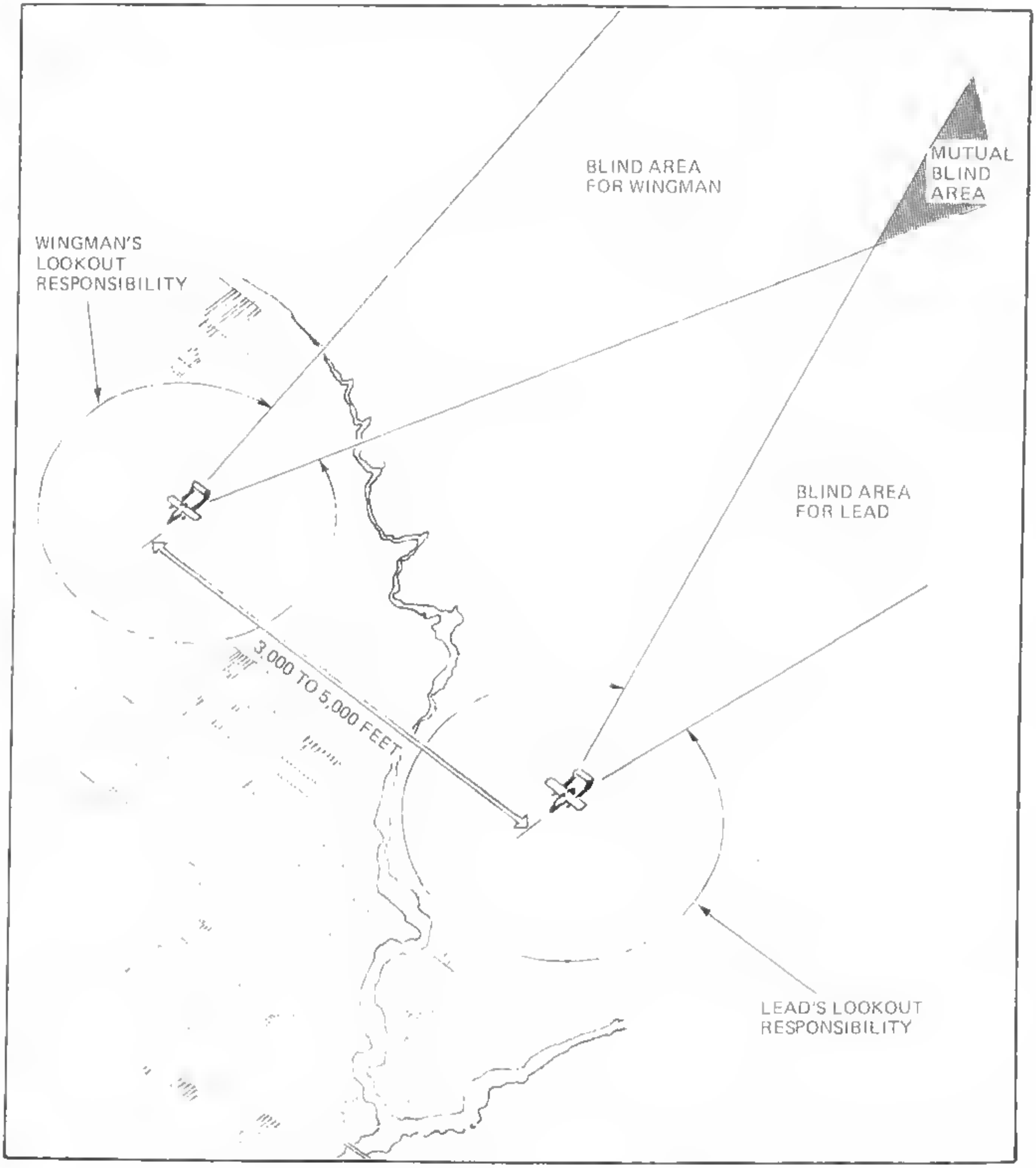


Figure 7-1. Combat Spread Formation (Sheet 1 of 2)

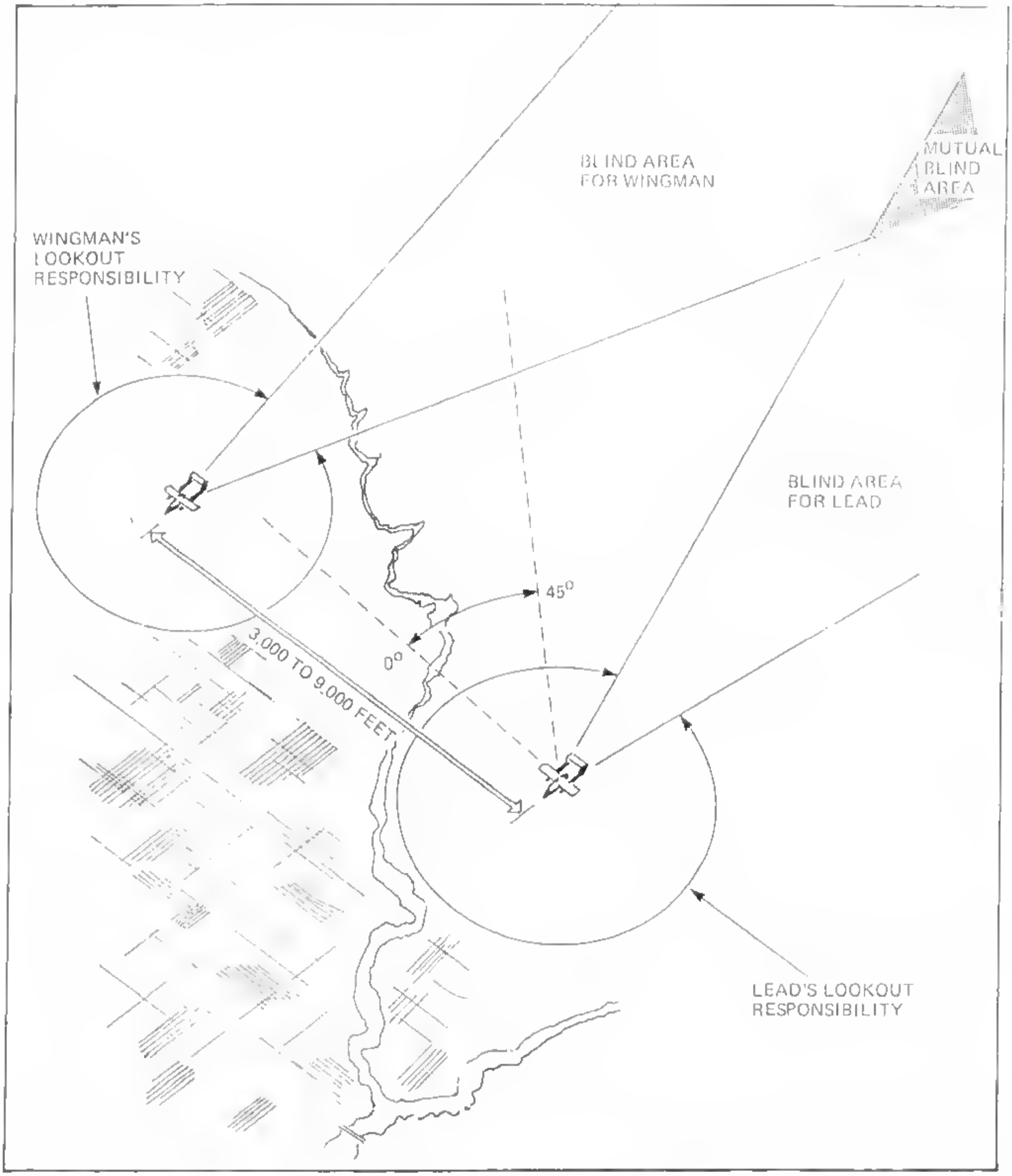


Figure 7-1. Combat Spread Formation (Sheet 2 of 2)

assets to support a specific engagement will also influence tactics.

3. Enemy situation — this includes the composition, location, disposition, and activities of enemy aviation and air defense units. The capabilities, weapons, and survival equipment of enemy aircraft should be considered.

4. Terrain and weather — terrain offers cover and concealment to aircrews that cannot or choose not to engage the enemy. Weather can place restrictions on all missions. Weather can affect acquisition and engagement ranges.

5. Weapons — onboard weapon capabilities will determine both the decision to engage and the tactics. It should be understood that the aircrew's capability to employ air-to-air ordnance will affect tactics used.

6. Aggressiveness — skilled aviators flying highly maneuverable aircraft can strongly influence tactics. Aircrews proficient in air combat maneuvering will be better able to evade or gain a superior tactical position.

7. Mutual support — mutual support by the wingman and other aviation assets is vital to survivability. It includes lookout techniques, team concept, and supporting fires from other aircraft and ground units.

8. Aircraft — consideration of IR signature, airspeed, g available, turn capability, and power available will affect tactics used in engaging all types of threat aircraft.

These and other tactical considerations will influence the way aviation units and their aircrews conduct air combat. This combat may be by individual or multiple aircraft and weapon systems. These tactical considerations should be used during both the planning and execution phases of each mission. Mission planning should provide an aircrew with the opportunity to decide when and where to engage an enemy. These considerations will also aid in decisions concerning avoiding the threat.

7.2.2 Antihelicopter Combat Tactics (AHCT). The OV-10 is a viable antihelicopter asset. The advantages of helicopters must be understood to be effective in countering them. These advantages are low-altitude flying (NOE), maneuverability, lookout with mutual support, and good fire control systems and weapons. Air combat against helicopters takes place in four stages: acquisition, closing maneuver, weapon employment, and disengagement.

7.2.2.1 Acquisition. Lookout techniques and visual acquisition have been discussed. As always, seeing the enemy first provides the time to make sound tactical decisions and to react. In addition to the previous considerations, the following checklist is provided:

1. Will the assigned mission be degraded by an engagement? Is the assigned mission to engage?

2. What friendly support is available and is it needed?

3. What is the composition and capability of the enemy flight? Are they escorted?

4. Does the terrain favor the enemy? Can the terrain be used to engage or withdraw?

5. What is the lethality and quantity of onboard weapons?

6. Knowing both friendly and enemy capabilities, is the engagement survivable?

7. Is the wingman capable of surviving the engagement?

8. Is the aircraft capable of surviving?

7.2.2.2 Closing Maneuver. When the decision is to attack, tactics must be determined. Aircrews should make every effort to remain undetected while maneuvering to a position where they can effectively engage and destroy an enemy. During this time it is essential to be prepared to respond if engaged first, especially by escort aircraft. It is possible that ground direct or indirect fire weapons can be used instead of a direct engagement. (The AO/SAC(A) can be used to contact these ground agencies.) If the aircraft cannot be maneuvered to a position of tactical advantage, air combat must commence immediately. In either case, attempt to use active and passive measures to remain concealed until gaining a tactical advantage. Ideally, the closing maneuver should terminate with an unobserved shot or a superior weapon's engagement position.

7.2.2.3 Weapon Employment. The third phase of AHCT is the most decisive and, possibly, most final. Weapon employment can consist of surface fires, attack/fighters that participate, direct fire weapons from the OV-10, or a combination of these. The goal of the attack is to fire first and destroy the enemy with all the shock and firepower available. If undetected in the attack, use the most accurate weapon to improve

first pass kill capability. If detected, engage the enemy at the farthest range possible and close until accurate fire can destroy the enemy. The longer an engagement lasts, the less survivable the participants become. The speed at which an aircrew can select and use weapons can affect the outcome of the fight.

7.2.2.4 Disengagement. Disengagement is the final stage. It consists of rapid and concealed exit from the air combat area. Historically, more aircraft have been destroyed during disengagement than during attack. This is attributed to many factors, but the greatest danger is aircrew complacency on egress. Disengagements are either free or forced:

1. Free — a free disengagement occurs when opposing aircraft have been destroyed or have withdrawn. It is the least dangerous disengagement.

2. Forced — a forced disengagement is dictated by circumstances such as low fuel, malfunction of/or depleted weapons, wounded crewmember, aircraft damage, or mission necessity. The OV-10 must use stealth, speed, and maneuverability to disengage. Successful disengagement causes the enemy to lose sight and not reacquire.

7.2.3 OV-10 Versus Jets. In almost all cases, air combat maneuvering against jets is defensive in nature. However, there are situations when offensive tactics are necessary and even desirable. The objectives of both defensive and offensive maneuvering against a fixed wing adversary are to continue the mission, survive the attack, deny the attacker positional advantage, and maneuver to obtain positional advantage to use onboard weapons. The stages of ACM against jets are similar to AHCT.

7.2.3.1 Acquisition. Once a jet is acquired, it must be determined if that jet is a threat to the flight and then use the tactical considerations checklist to determine actions. In deciding if attack is imminent, it must be understood that jets have to execute recognizable maneuvers before they attack. Usually these maneuvers include climbing to gain an altitude advantage, circling overhead, or pointing directly at the flight. It is possible that a jet will lose sight during a popup type attack and the OV-10 should use this time to maneuver to a position that prevents reacquisition. Speed can be a disadvantage for jets as they require a large turn radius that can take them out of visual range.

Receiving fire is another indication that an OV-10 is under attack and ACM must be instantaneous in order to survive. Three-dimensional maneuvering must be used to break a tracking solution and aid in obtaining an offensive posture.

7.2.3.2 Closing Maneuver. Closing maneuvers will usually be performed by the adversary. However, if the OV-10 is assigned an antiair warfare role, maneuvering to a position in between the attacking aircraft and the vital area may have to be performed. During the closing maneuver of an enemy, the OV-10 must be maneuvered to deny firing parameters to the enemy and/or achieve offensive firing parameters for onboard weapons. The initial maneuvers are similar for both cases. The attempt should be to make the first pass head on and then maneuver to protect from a second aircraft or shoot the initial aircraft.

7.2.3.3 Weapon Employment. Weapon employment objectives are similar to AHCT. However, against jets the use is defensive in nature for self-protection.

7.2.3.4 Disengagement. Avoidance may be essential for mission performance. Once engaged, disengagement may be required for accomplishment of the assigned mission, especially if no air-to-air weapons are carried. Disengagement is more difficult from jets because of their speed advantage. It can also be more risky because of the weapon capabilities of jets. Aircrew should be prepared to use minimum altitude capable (MAC) and terrain masking to disengage. Try to use a jet's limited visibility to disengage.

7.3 TACTICAL FORMATION (TACFORM)

Tactical formation is the coordinated and mutually supporting method by which a section of OV-10's may travel to, and operate in, the battle area. When flown effectively, TACFORM enhances the offensive and defensive capabilities of the OV-10.

7.3.1 Positioning. Tactical formation is flown utilizing the standard, mutually supporting, combat spread formation. The wingman position is directly abeam, coaltitude, and 3,000 to 5,000 feet away from the lead aircraft (Figure 7-1). Terrain, visibility, and enemy situation all effect just how closely abeam the section will operate. When operating over open desert, plains, or woodlands, the lateral spread can increase with visibility being the only limiting factor. This wide lateral spread is also desirable in high density AAA, SAM, and enemy air areas as it minimizes the possibility that both aircraft are spotted by a single enemy (either visually or on radar). In mountainous areas, the terrain will dictate how close abeam to lead the wingman must fly in order to remain in visual contact.

7.3.2 Lookout. Good lookout doctrine cannot be overemphasized, for without it, a primary advantage of tactical formation is negated. The pilot's primary lookout responsibilities should be forward and toward the other aircraft. The observer's primary lookout should be to the

flanks and rear flanks. The wingman aircraft has the added responsibility, for both pilot and observer, of seeing the lead's uncalled turn signals when given. Neither aircrew should rely completely on the other for the clearing of their own 6 o'clock position. Between maneuvers, both aircraft should be rocking their wings, every few seconds, to facilitate their own six check by looking over and under the tailbooms. This wing rocking procedure should be done in a slow and easy manner so as not to draw attention to the section or cause the other aircraft to confuse it for a wing flash. Continuous route orientation is important to navigation and essential in keeping the aircrew's heads out of the cockpit as much as possible.

7.3.3 Radio Calls. In a rapidly changing aerial environment where instant recognition of meaning is critical, the following terms need to be understood by all, when flying effective formation and maneuvering against an enemy:

1. VISUAL — other aircraft has sight of wingman.

2. NO VISUAL — other aircraft does not have sight of wingman.

3. TALLY — either aircraft has sight of bogey.

4. NO JOY — aircraft has no sight of bogey.

5. IN — aircraft is commencing tracking run on bogey or attack run on target.

6. OFF — aircraft has completed tracking run on bogey or attack run on target.

7. ENGAGED — aircraft currently maneuvering against a bogey that is maneuvering on him.

8. FREE — aircraft that is not engaged and can maneuver by himself or through calls from engaged aircraft to successfully engage or attack bogey.

9. WINCHESTER — ammunition expended.

10. PADLOCK — aircraft that has visually locked on a bogey or target and cannot afford to look away, then assumes tactical lead of other aircraft and will call all turns to engage.

Bogey calls should be given, "RIGHT 5, LEFT 8," and so forth, for simplification of understanding and in reference to the aircraft clock codes. Tactical call signs, aircraft side numbers, or personal call signs may be used once an engagement is entered. Any and all calls to the other aircrew should be clear, concise, and in understandable terminology.

7.3.4 Maneuvering. Tactical formation maneuvering is a method by which the flight lead directs the positioning and navigation of his section through called and uncalled turns.

7.3.5 Formation Turns. When flying TACFORM, all calls or visual aircraft signals for turns will be initiated by the lead aircraft. The only occasions where this will not be true are when the wingman has initially become the engaged aircraft, has spotted the target prior to lead and lead has not initiated engagement or attack, or wingman has called, "PADLOCK." When performing all turns, each aircraft should strive to retain maximum airspeed while engaged or be consistent with section integrity. No more than 3g's should be necessary or used because of loss of airspeed, which is critical in the OV-10. The wingman has the responsibility for lead's 6 o'clock at all times. When giving visual signals with the aircraft, they should be definite, as should initial turns after each signal. This is particularly important since the wingman should not be in a position where mutual support is lost. A thorough map study and route orientation can greatly alleviate any misunderstandings at predetermined points. Wing flashes, used to initiate many turns, will be 90° wing rocks, showing the wingman either the top or bottom of the aircraft. This signal, when given by the lead, means that the wingman should start a turn into the lead aircraft. During the execution of each turn, both aircraft should check each others' deep six and their mutual blind area. When using radio calls to initiate turns, the type turn will be called, followed by the execution command GO. Uncalled signaled turns will be initiated immediately, or very soon after the signal command is given. It will be the wingman's responsibility throughout to maintain position on the lead, using turns away or power/altitude changes, as necessary. However, this does not preclude lead from using turns, turns away, or power changes to help the wingman get back in position.

7.3.5.1 Ninety-Degree Turn Into Lead. Initiated by wing flash or right/left (R/L) 90 Go, wingman rolls to 60° angle of bank (AOB) towards lead's 6; when wing passes in area of lead's 5/7 o'clock position, lead will start a turn to arrive at the desired degrees of heading change. In the case of all 90° turns, this will be from 60° to 120° off the original heading. Wing can roll out after 90° of change and then adjust abeam distance and heading once lead has reestablished (Figure 7-2).

7.3.5.2 Ninety-Degree Turn Away From Lead (Into Wingman). Lead initiates by a 60° AOB turn or greater into wing, or calls, "R/L 90 — GO." Wing starts turn when lead is in his 5/7 position and adjusts on lead's new heading of 60° to 120° off original (Figure 7-3).

7.3.5.3 One Hundred Eighty-Degree Turn Into Lead/In-Place Turn. Lead starts with a wing flash or

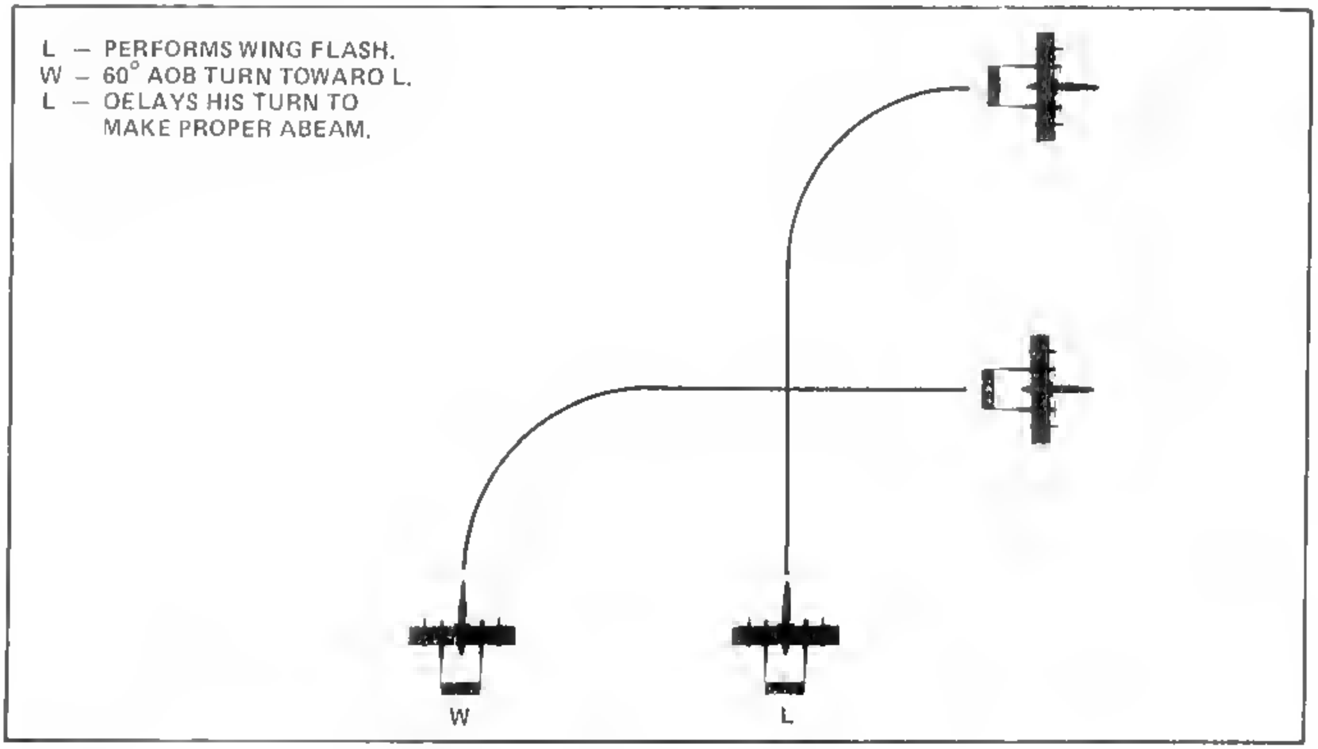


Figure 7-2. 90° Turn Into Lead

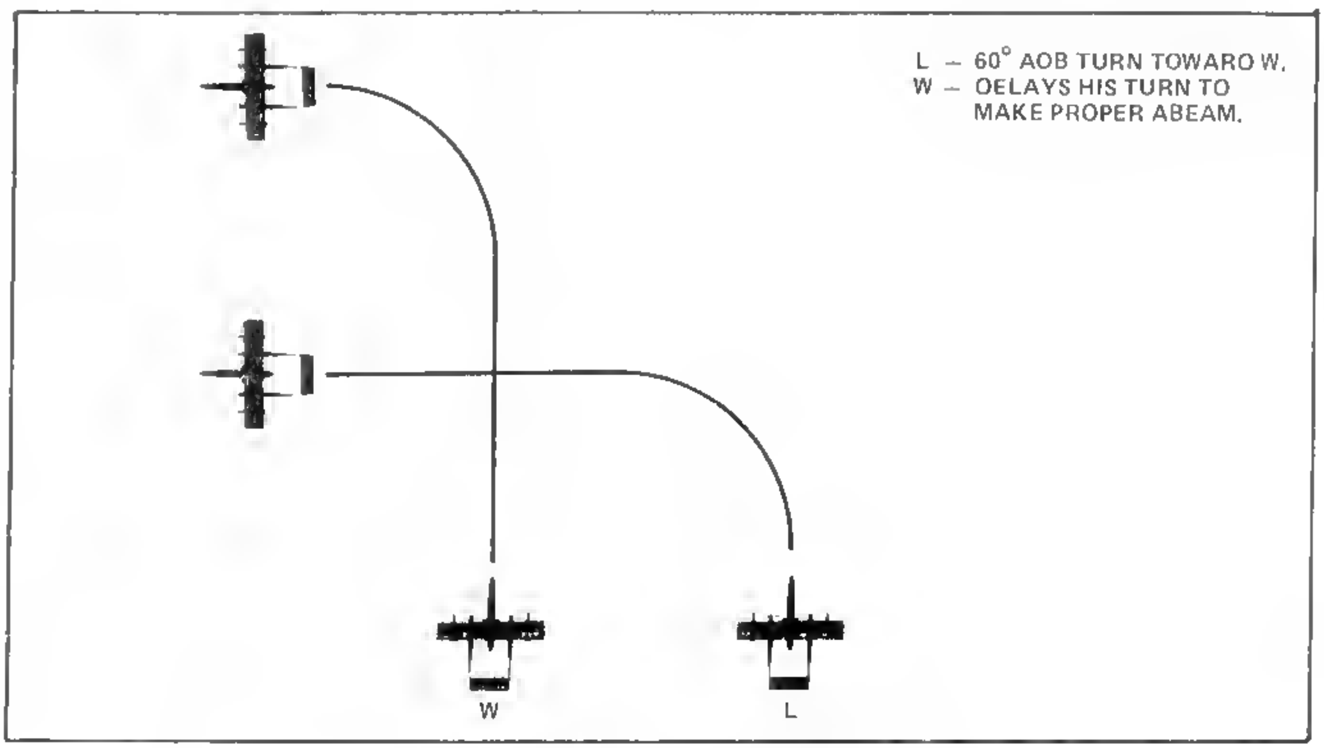


Figure 7-3. 90° Turn Away From Lead

calls, "R/L 180 — GO." Once wing has started his turn into the lead, lead will immediately roll to 60 ° AOB or greater. Wing will then match lead's AOB and continue on around to a heading 150° to 210° opposite the original. Wing adjust after rollout turn should be done coaltitude (Figure 7-4).

7.3.5.4 One Hundred Eighty-Degree Turn Away From Lead. Lead starts with a 60° AOB turn or greater into the wing, or calls, "R/L 180 — GO." As lead passes wing's 5/7 he starts his turn and turns to 60° to 120° off original heading. When lead observes wing rolling out, he gives a wing flash or calls, "R/L 90° — GO." Wing now commences a 60° AOB turn into lead, who will then turn to the final heading, 150° to 210° off original when wing passes his 5/7. Wing adjusts position (Figure 7-5).

7.3.5.5 Crossturn. Lead starts with a wing flash to wing or calls, "CROSSTURN — GO." Lead immediately rolls to 60° AOB or greater; wingman starts turn to match lead's AOB and crosses outside of lead's radius. Both aircraft check 6 and continue on around to 150° to 210° of turn opposite original heading. Care must be taken on the part of lead to start his turn to the wingman immediately after the signal/command is given. This is to ensure that the wingman can easily stay outside of lead's turn and not set up a crossing point at the center or force lead to the outside. When crossing, aircraft should attempt to be coaltitude to present the least amount of a visual indication of presence (Figure 7-6).

7.3.5.6 Thirty-Degree or Less Turn. Lead aircraft will simply turn the desired number of degrees R/L, or call R/L the number of degrees — GO. Turn will be done with a shallow angle of bank (less than 20°), wingman adjusts as necessary.

7.3.5.7 Forty-Five-Degree Turn Into/Away From Lead. To start a 45° turn into lead, he will give a wing flash to the wingman or call, "R/L 45 — GO." Wing then begins turn to lead. Immediately after lead sees wing commence his turn, lead begins a shallow AOB turn away from the wing. The shallow AOB clues the wing that it is a 45° turn and not an in-place turn, so he eases out his AOB to stay on the same side of lead he began. Lead rolls out to new heading (30° to 60° off original) and wing approximates. Lead now is a good distance in front of wing and so does a turn away, using as much angle away as necessary to allow wing time to catch up. In the turn away, lead will check the section's deep 6 before resuming course. Forty-five-degree turns away from the lead, or into wingman, are initiated simply by lead starting a shallow AOB turn into wing or calling, "R/L 45 — GO." The shallow AOB will tell wing it is not a 90° turn and so can expect a turn to 30° to 60° off original heading. Lead will stay on the same side that he started and roll out at the new heading. Wing now is in front and so will execute a turn away, checking deep six, then resuming course and position (Figure 7-7).

7.3.5.8 Weave Turn. Initiated by a wing flash from lead, or call, "WEAVE —GO." Lead turns into wingman, leveling wings after 30° to 45° of heading change. Wing is to cross behind lead and both aircraft check deep 6. It is a maneuver useful along long straight legs to improve lookout to the rear of the section (Figure 7-8).

7.4 COMBAT FORMATION MANEUVERS

Aircrews use basic TACFORM maneuvers and advanced maneuvers in air combat. Advanced maneuvers include those maneuvers that negate a threat aircraft attempting to attack and provide for positioning for weapon employment. Some of the advanced maneuvers are initiated in combat formation and some individually. These maneuvers give the tactical flight leader maximum command and control of the flight while increasing the flexibility and airspace for individual aircraft to maneuver. Additional combat maneuvers can be found in NWP 55-6-OV10A/D, Vol. II.

7.4.1 Control of the Flight. In an air combat maneuvering environment, there are two leadership positions for tactical control of the flight: the flight leader and the tactical leader. The flight leader or designated formation leader is responsible for organization and control of the flight from beginning to end. The tactical leader is the aircrew/pilot with the best grasp of the tactical situation and, therefore, in the best position to direct the flight. The tactical lead is not determined by rank, experience, or ability. Defensively, the tactical lead maneuvers the flight to negate the threat and is usually the one engaged. Offensively, the tactical lead is engaged and attempting to use onboard weapons. The tactical wingman is responsible for maintaining separation from lead, covering the flight from additional engagement, and providing mutual support.

7.4.2 Types of Maneuvers. The types of maneuvers and their purposes follow. Additional maneuvers can be found in NWP 55-6-OV10A/D, Vol. II.

7.4.2.1 Engaging Turns. The purpose of the engaging turn is to position the flight for an offensive (helicopter) or defensive (jet) maneuver while maintaining the energy state of the aircraft. These turns are similar to tactical turns being about 60° angle of bank (AOB) and two "g's." Normal tactical turns may be used as engaging turns. If used against jets, the engaging turn is used to effect a head-on pass. Against helicopters it is

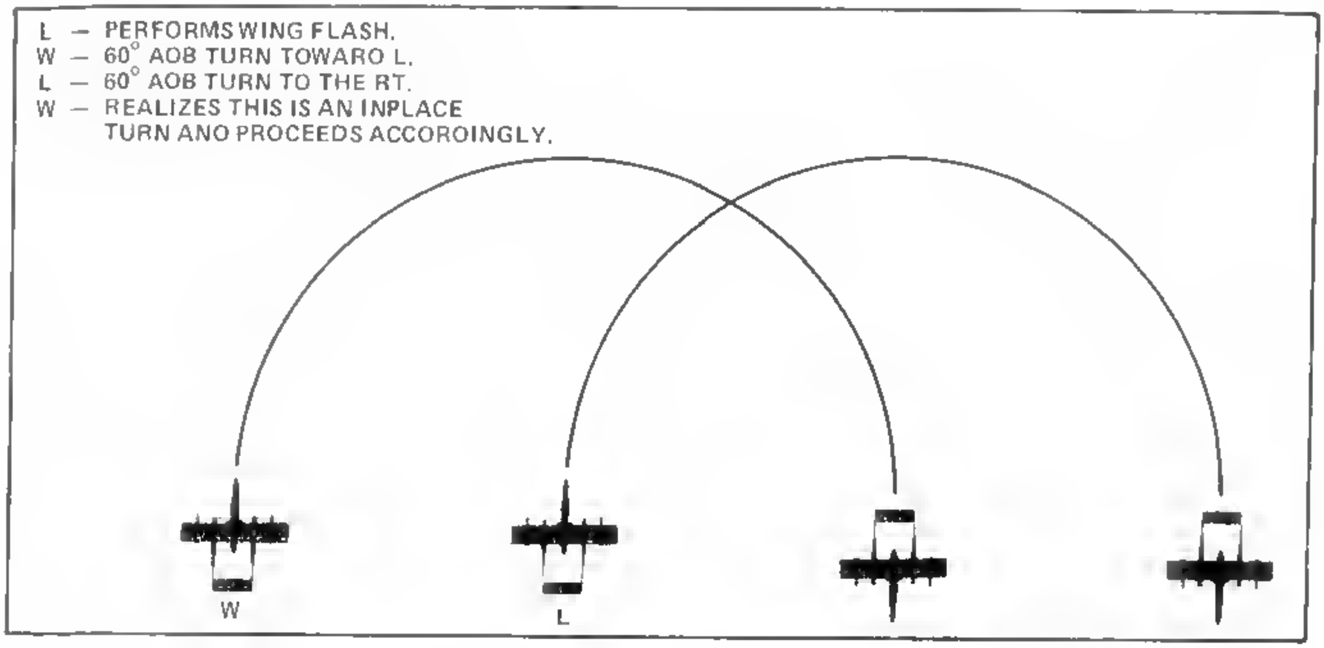


Figure 7-4. 180° Turn Into Lead, In-Place Turn

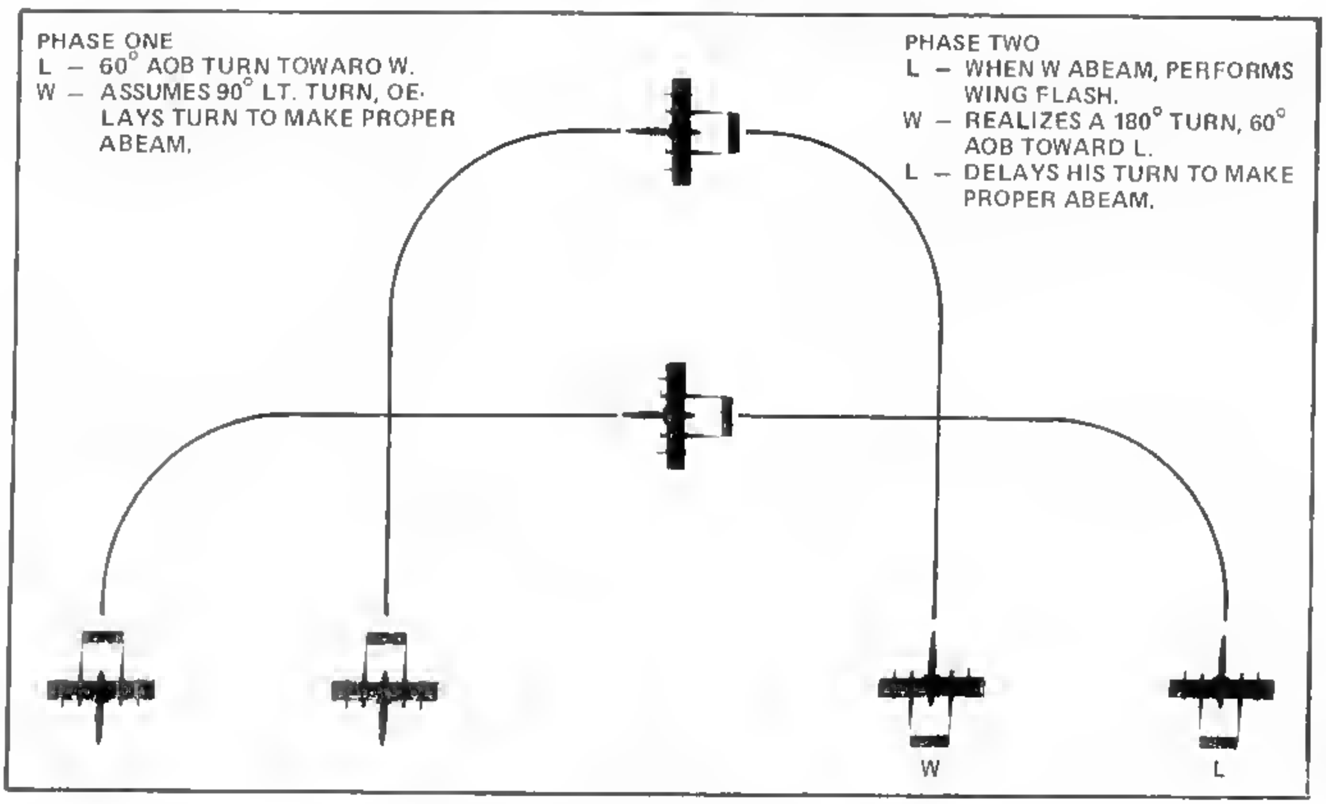


Figure 7-5. 180° Turn Away From Lead

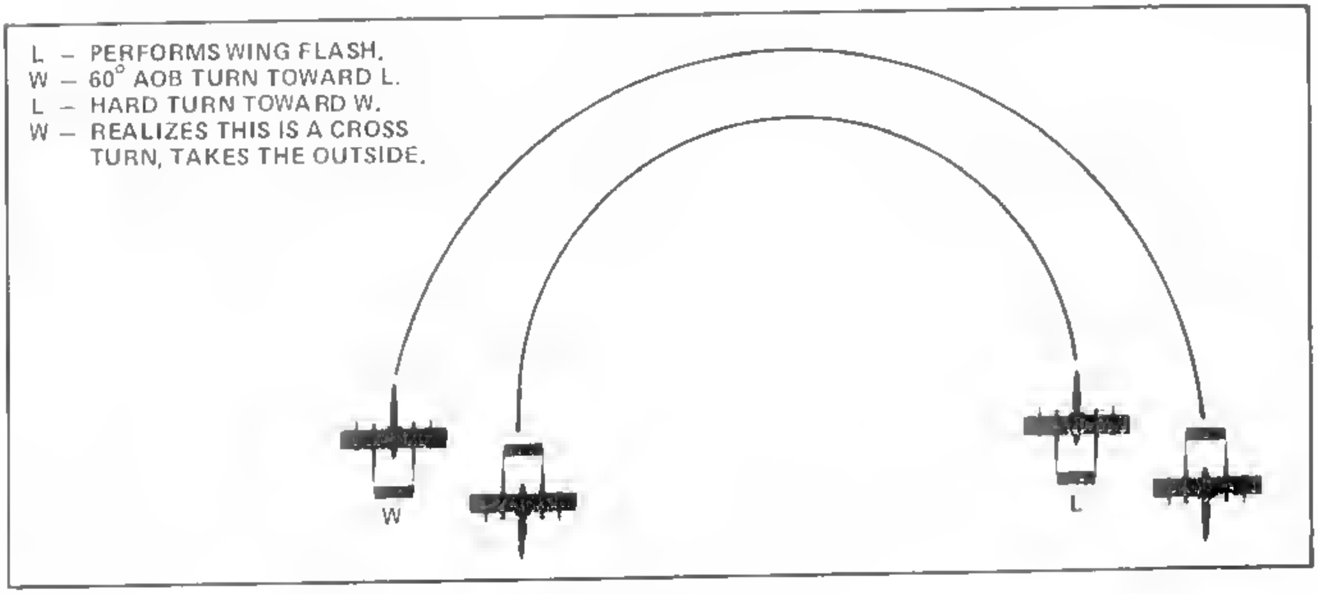


Figure 7-6. Crossturn

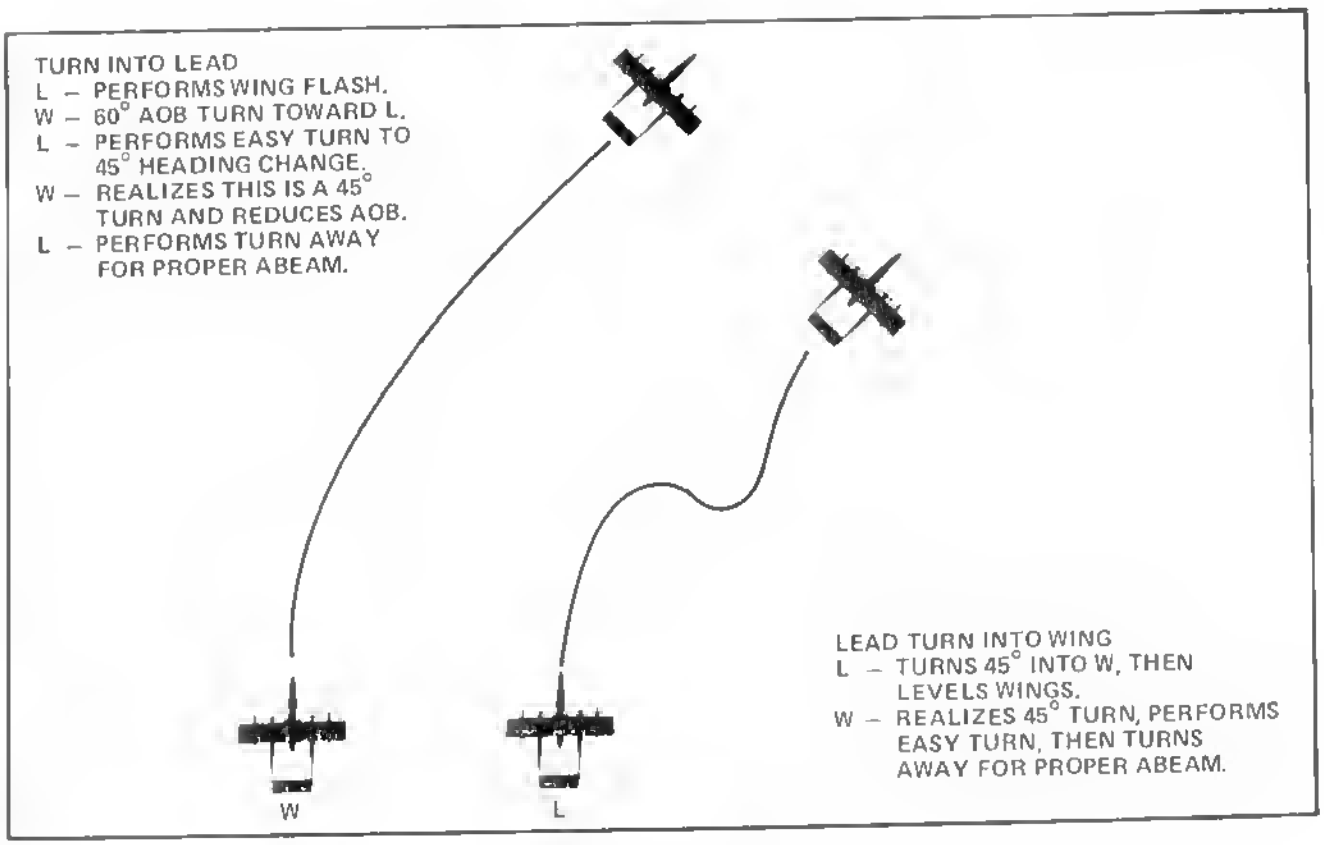


Figure 7-7. 45° Turn

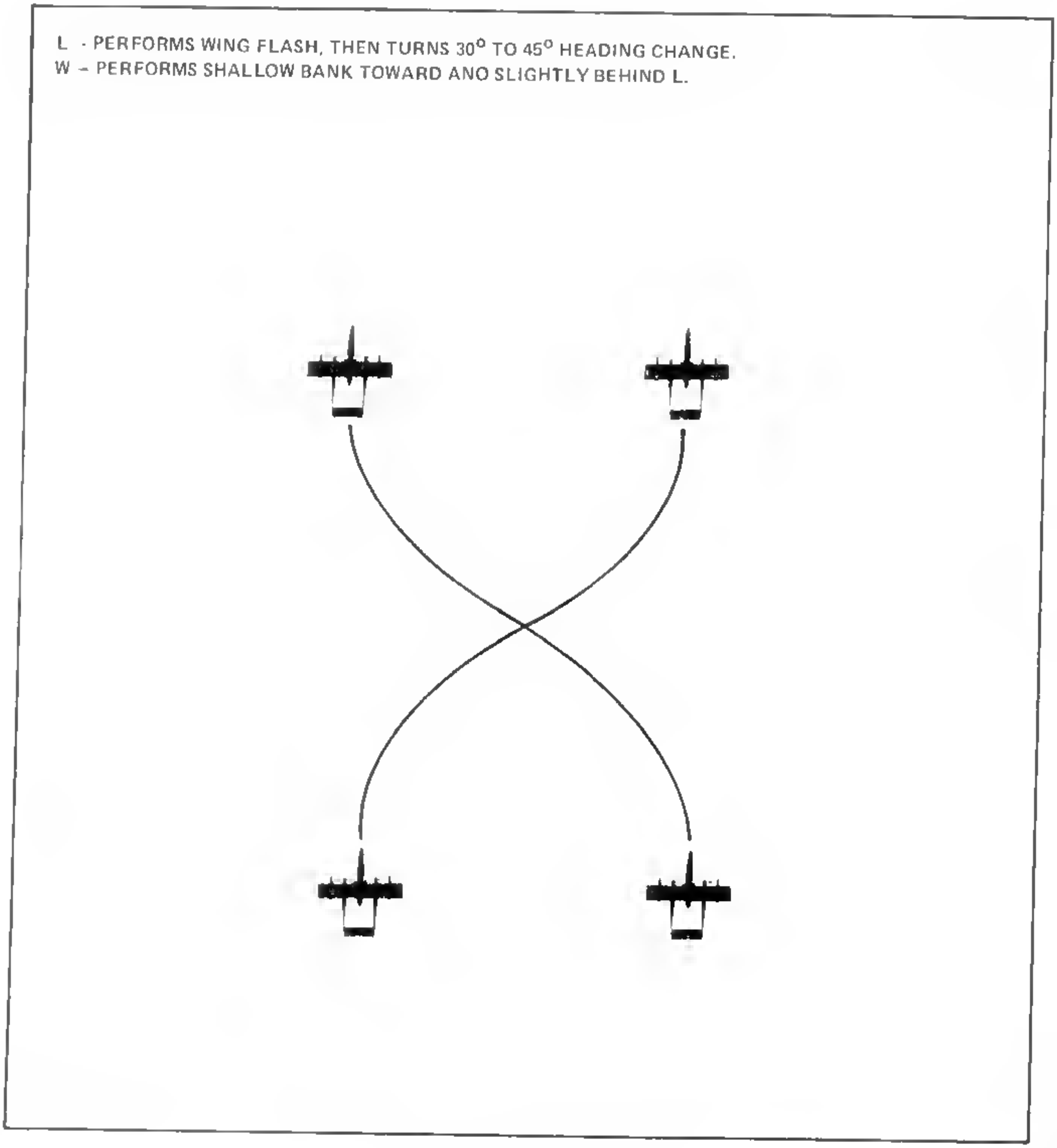


Figure 7-8. Weave Turn

used for a simultaneous attack or to position for a split turn attack.

7.4.2.2 Break Turns. The purpose of the break turn is to break out of the firing solution an enemy aircraft has or is maneuvering toward. The break turn is defensive in nature and does not require energy conservation. The break turn is a survival turn that uses the "g" and altitude necessary to defeat the enemy. The break turn should be three dimensional and into the attacker attempting to fly under his aim point. Break turns are also capable of defeating air-to-air weapons.

7.4.2.3 Split Turns. The purpose of the split turn is to separate the flight for defensive and/or offensive maneuvering. Defensively, a split turn separates the flight and reverses the direction of flight. This decreases the possibility of simultaneous engagement of the flight from the rear while increasing the lateral separation. Offensively, split turns provide for both simultaneous and wingman-delayed attacks from different directions or altitudes. There are four basic types of offensive split turns.

7.4.2.3.1 Vertical Split. The vertical split provides altitude and time separation between the lead and wingman in the attack. When initiated by the tactical lead, the wingman climbs and uses some gentle turns to provide time (10 to 20 seconds) and altitude (800 to 1,500 feet) separation between aircraft. This altitude separation does not preclude lead from using a popup type maneuver to attack. Slight directional change by the wingman can cause some difference in attack direction; however, the main objective is to provide altitude and time separation.

7.4.2.3.2 Horizontal Split (90°). The purpose of the 90° horizontal split is to position the section to attack from different directions (perpendicular) with a 15- to 30-second time delay between lead and wing. When initiated by lead, "SPLIT 90," wing performs a 20° to 40° heading change away from lead and follows a circular route to arrive with a 15- to 30-second delay and perpendicular (90° off) with respect to lead's position. This split can be initiated from any quarter against helicopters.

7.4.2.3.3 Horizontal Split (180°). The purpose of this type horizontal split is to produce an attack on a flight of helicopters from opposite directions either simultaneously or with a time split. This maneuver is initiated with a time split. This maneuver is initiated with "SPLIT 180" and performed by both aircraft turning away about 30° to 45° heading and flying a circular route to attack from opposite directions. When initiated from a position abeam and perpendicular to the threat, the result is a time split of 15 to 45 seconds.

7.4.2.3.4 Time Split. The purpose of this split is to provide a time separation attack from the same direction and altitude (in plane). When initiated "GO TRAIL," the wingman uses turns to position his aircraft 1 to 1.5 miles behind lead. This will result in a 20- to 30-second time separation between aircraft. This split is useful when maneuvering the section using low altitude and terrain to achieve an unobserved rear quarter attack.

7.4.2.3.5 Split Considerations. All of the split turn descriptions, except the time split, consider that the flight is in a position to initiate the split and immediately attack the helicopters.

7.4.2.4 Yo-Yos. The purpose of the yo-yo is to affect nose-to-tail separation and reduce angle off while maintaining the energy state of the aircraft.

7.4.2.4.1 High Yo-Yo. The purpose of the high yo-yo is to increase the nose-to-tail separation and reduce angle off. It is used when attempting to gain a gun tracking solution against an equal or slower adversary that is ahead and turning. The maneuver is performed by reducing the AOB and climbing to a position above and behind the bandit. The turn rate is then increased to realign the aircraft, and then the nose is lowered to obtain a gun tracking solution.

7.4.2.4.2 Low Yo-Yo. The purpose of the low yo-yo is to decrease nose-to-tail and reduce angle off. The maneuver is performed by increasing AOB, but not "g" and allowing the nose to drop slightly. The aircraft will fly below the bandit and accelerate, increasing the closure rate. Once proper nose-to-tail is achieved, reduce the AOB and raise the nose to obtain a gun tracking solution. Low yo-yos are not effective at low altitudes.

7.4.2.4.3 Lead and Lag Turns. Lead and lag turns are performed in the horizontal plane to affect nose-to-tail separation for gun firing parameters. Lead turning is pointing the nose of the aircraft to a position in front of the bandit to decrease the nose-to-tail separation and close to gun firing range. Lag turning is pointing the nose of the aircraft behind the enemy to increase nose-to-tail separation to achieve a gun firing or missile range.

7.5 MANEUVERING AGAINST HELICOPTERS

7.5.1 Section Considerations. Before performing section air combat maneuvers, all aircrews must be thoroughly familiar with the maneuvers and commands to be used. Thorough briefing is required to improve survivability and success. The briefing should include lookout responsibilities, weapons to be used, mutually supporting attacks, and disengagements. Recom-

mended briefing items will be discussed, but are not limited to these items.

7.5.1.1 Lookout Responsibilities. The lookout techniques previously discussed are only guidelines for flight planning and execution. Lookout responsibilities for specific maneuvers and while performing specific missions should be briefed by the mission commander or flight leader. The primary responsibility of the wingman is to protect the flight leader from attack. His lookout responsibilities and techniques shall be dictated by lead and common sense in covering lead. If the mission is AHCT, the flight leader will brief search patterns and lookout responsibilities.

7.5.1.2 Engaged and Free Aircraft Responsibilities. Once ACM has been initiated, usually one aircraft is engaged with the threat and the other is free to maneuver to a position to take over the engagement or protect the flight from other aircraft. The engaged aircraft is tasked with maneuvering to destroy the enemy. The engaged aircraft can also use the position to decoy the enemy to a position allowing the wingman to attack.

The free aircraft is free to maneuver to a position of advantage and cover. This position is usually above the flight of helicopters and such that he can immediately attack. The reason a position above the flight is used is to deny the airspace to the helicopters and visually acquire other aircraft (high cover). The best technique in attacking helicopters is to systematically alternate roles, bringing continuous attack and fire on the helicopters. Different techniques can be used to accomplish this out of phase, continuous attack. It is important to eliminate the enemy as quickly as possible and egress the area. Communication is essential to coordinate the attack on helicopters. It is also important to communicate "ENGAGED" or "FREE" to the other aircraft. Good communication techniques will be discussed later.

7.5.1.3 Weapons. In addition to the previously discussed weapon use, weapons can be used to distract an enemy while the free aircraft is maneuvering for an accurate shot. In light of this, if the tactical lead (engaged aircraft) is not in position to get a kill, he should use his position and weapons to set up the wingman.

7.5.1.4 Mutually Supporting Attacks. Previous information discussed the responsibilities of the tactical lead and wingman during an engagement with helicopters. Additionally, aircrew should be briefed on the types of attacks and advanced maneuvers to be used in attacking helicopters.

7.5.1.5 Disengagements. Section disengagements are the responsibility of the flight leader. Flight lead will make the decision to disengage and brief the wingman's tactics during disengagement. One of the methods to perform a forced disengagement is to communicate "BUGOUT" at a point when the adversaries are the least capable of maneuvering for a retaliatory shot. During a systematic section attack, the free aircraft will probably be above and ready to engage. When a bugout is called, the free aircraft dives to assume a normal combat spread position. The free aircraft uses the altitude to increase speed on egress. The engaged aircraft will use a simple extension type maneuver away from the fight. If reattacks are to occur after a disengagement, it should be briefed.

7.5.2 Section Maneuvers. Advanced section maneuvers have been discussed. Offensive split turns can be used to engage or a simple simultaneous attack can be used. The split attacks will cause an out-of-phase and/or out-of-plane attack. The following are some of the possible ways to perform attacks against helicopters.

7.5.2.1 Simultaneous Attack. The simultaneous attack is usually used for chance encounters or to engage two helicopters simultaneously in a flight. The purpose of attacking simultaneously is to provide shock and either disorganize the enemy or quickly disengage. This type attack is usually a reaction to an immediate threat and it is used to gain the offensive as quickly as possible. The flight leader will determine actions after a simultaneous attack.

7.5.2.2 Vertical Split. The vertical split provides an initial out-of-phase attack and easily becomes an out-of-phase and out-of-plane reattack. Some directional difference can be used in the attack and it would be advantageous. A continuous flow, out-of-phase (one high, one low) air combat sequence is hard to defend against.

7.5.2.3 Horizontal Split (90°). The 90° horizontal split is shown in Figure 7-9. It provides an out-of-plane and out-of-phase attack on the enemy. In addition to attacking from different directions, this attack flows smoothly into the continuous attack engagement. If it is initiated from the abeam position, it is possible that the attack will be from different directions simultaneously. This will make the enemy choose which threat to honor. It is difficult to get an out-of-phase reattack established after a simultaneous attack.

7.5.2.4 Horizontal Split (180°) This maneuver is shown in Figure 7-10. This attack provides the capability to attack an enemy from opposite directions either simultaneously or with a time split. This type attack also causes the enemy to have to choose.

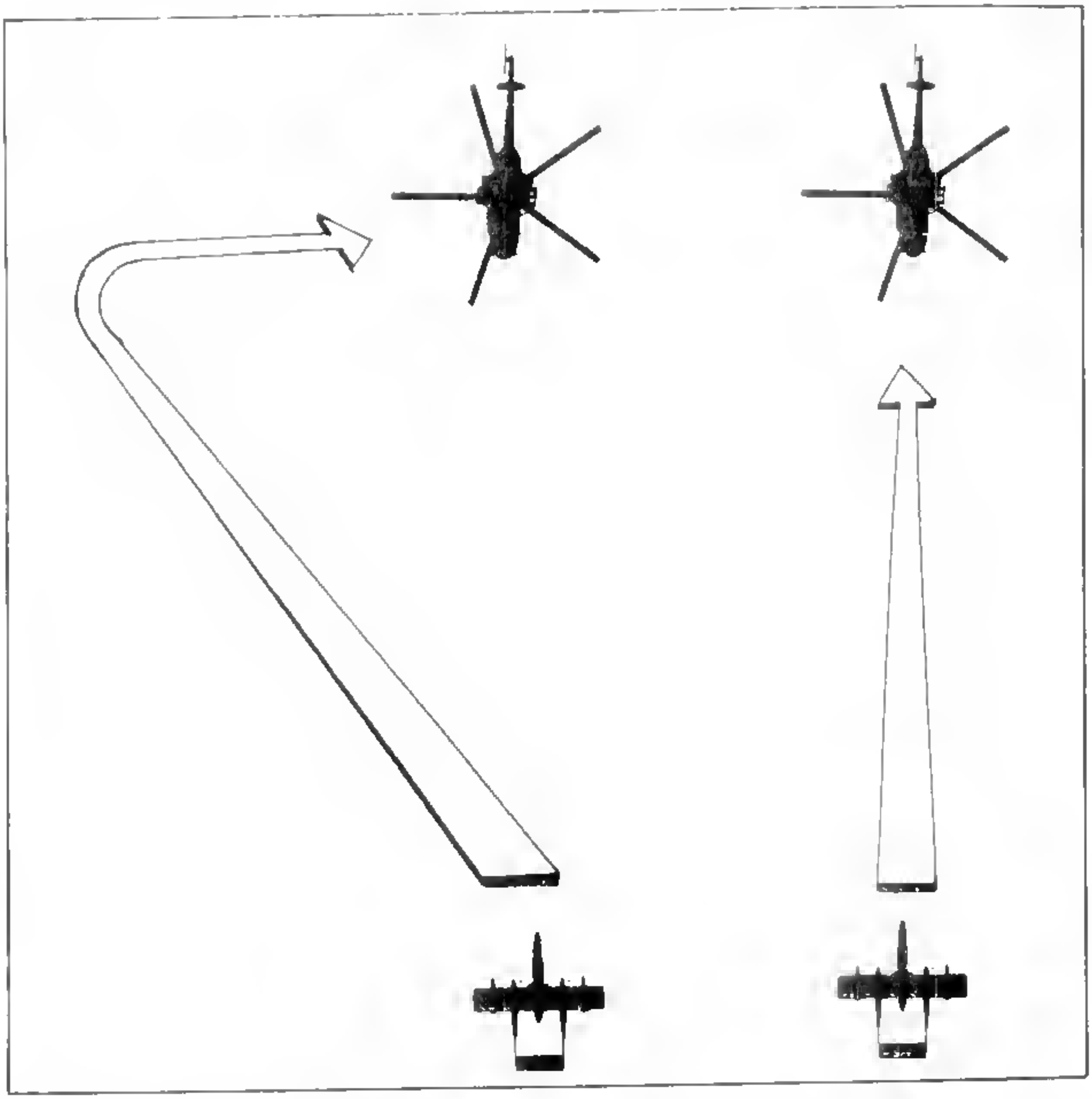


Figure 7-9. Horizontal Split (90°)

7.5.3 Section Communications. Good communications is necessary when fighting as a section. The coordination of the flight will depend a great deal on the ability to call the enemy location and coordinate the initial attack and reattacks. Keeping radio transmissions simple and concise will aid in achieving timely action against the enemy. An example of good communication follows:

Tactical lead (TL): "2 HINDS, RIGHT 2 O'CLOCK, 1 MILE, VERTICAL SPLIT. I'M ENGAGED." (Lead padlocks and selects weapons and attack profile.)

Tactical wingman (TW): "TALLY ONE, VISUAL, VERTICAL SPLIT. I'M FREE." (TW performs vertical split, selects weapons, maintains visual and tally, and has AO/SAC(A) clear flight.)

TL: "LEAD'S OFF, EXTENDING."

TW: "(CALL SIGN) IN, TALLY 2, VISUAL."

TW: "(CALL SIGN) OFF, GOING RIGHT, VISUAL."

TL: "LEAD'S OFF, VISUAL, SPLASH ONE, AFTER ATTACK, BUGOUT SOUTH, VISUAL."

TW: "(CALL SIGN) IN, TALLY 1, VISUAL, ROGER SOUTH."

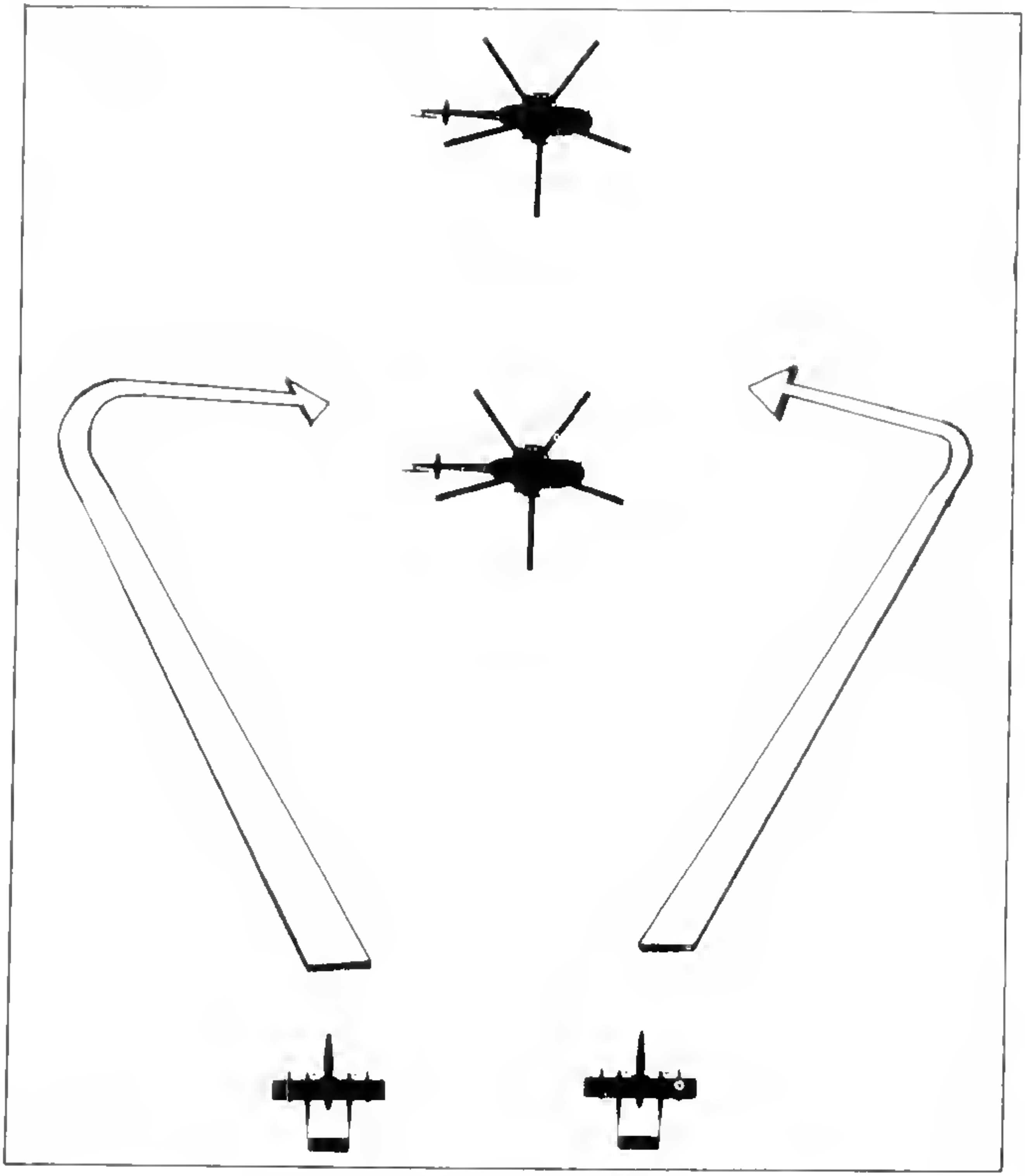


Figure 7-10. Horizontal Split (180°)

TW: "(CALL SIGN) OFF, SPLASH NUMBER 2, VISUAL."

TL: "ROGER, VISUAL, JOIN CRUISE, HEADING 155."

7.5.4 Single Aircraft Attack Helicopter Countermeasures (AHCT). Though the OV-10 is superior to most helicopters, new threat helicopters will be comparable in speed and weapons. Currently, experience level being equal, an OV-10 should defeat an enemy helicopter. Care should be taken when engaging a flight of two or more helicopters, especially if they are attack helicopters. Tactically, OV-10's should always operate in a combat environment; however, single aircraft tactics will be discussed.

After the initial attack, it is difficult to outmaneuver a single helicopter. Do not try to fight a close fight with the helicopter considering its advantages. A popup maneuver should prevent a helicopter from using forward firing ordnance. Upon commencing an attack, expect the helicopter to turn into the fight forcing a head-on pass. Attempt to dive in the position that leads to the flightpath of the enemy and shoot weapons allowing the helicopter to fly through the shots. At the merge, the helicopter will turn the shortest direction to the OV-10's 6 o'clock. Attempt to deny this by turning slightly away from his direction of turn and extend at maximum speed away from the fight. Fly out of range of the enemy and then attempt to reengage from a different direction. The objective of the engagement should be:

1. Acquire

2. Close to firing range

3. Extend out of range

4. Cause the enemy to lose sight

5. Reengage.

The extension is flown to minimize the amount of time the OV-10 is in the lethal range of the helicopter. Extend at the maximum airspeed and minimum altitude. If possible, use terrain masking. Use of the vertical while still in range is for section tactics or fighting an inexperienced helicopter driver. Also, an attack from directly above the helicopter is difficult. The extension will require 1.5 to 2 minutes to achieve the distance necessary for a successful reattack. After the extension, the OV-10 can reverse back toward the helicopter or disengage and attempt to reacquire from a different direction.

7.6 MANEUVERING AGAINST JETS

7.6.1 Section Considerations. Briefing of commands and maneuvers is similar to AHCT except the threat is coming from an altitude above rather than below. Lookout responsibilities are the same, but combat maneuvering responsibilities are different.

7.6.1.1 Engaged and Free Aircraft Responsibilities. The main difference in ACM against jets is that it is defensive in nature. This does not preclude using onboard offensive weapons to defend the flight. The main objective is to defeat the threat early with an all-aspect missile, if possible. During the initial part of the engagement the OV-10 maneuvers defensively to prevent engagement, and then uses the good maneuverability to use a retaliatory shot to prevent reattack. In other words, the engaged aircraft maneuvers defensively while the free aircraft covers the flight from attack by other aircraft. The engaged aircraft may maneuver for a shot if the free aircraft has cleared the flight from other attacks. (When possible, use low-altitude maneuvering and terrain to prevent engagement.) The free aircraft calls bandit positions and maneuvering turns from his covering position.

7.6.1.2 Weapons. Like AHCT, weapons should be used at their maximum effective range. This includes an all-aspect missile, if available. Exact firing parameters of the AIM-9 can be found in NWP 55-6-OV10A/D, Vol. II. Guns can also be used against in-range jets.

7.6.1.3 Mutually Supporting Attacks. Since the threat tends to fly in large formations and the supply of missiles is limited, a section of OV-10's should attempt to avoid engaging the same aircraft simultaneously. This can only be accomplished with good procedures and good communication. The main mutual support offered by a section is lookout. Once engaged at low altitude, it is possible to achieve an in-plane, out-of-phase maneuver to offer mutual protection. Never forget, however, that the main goal is to avoid or shoot as early as possible if avoidance is impossible.

7.6.1.4 Disengagements. In a multibandit environment it is difficult to make the enemy lose sight. Maneuver in section is used to neutralize the enemy until he reaches bingo fuel. Avoid long engagements if possible. Most enemy jets will attack with only one reattack. Defensive maneuvers should only be needed for about 2 minutes. If the enemy has onboard radar, it will make disengagement even more difficult.

7.6.2 Single Aircraft Maneuvers. Single aircraft maneuvers are discussed first as some of them are applicable to section maneuvering. The initial turn in an engagement is to put the attacker in an abeam position.

When the attacker has closed to missile range, turn into the bandit for a head-on pass. This is almost always the optimum defensive maneuver. (Figure 7-11 illustrates the types of engaging turns to be used against jets attacking from different quarters and distances.) A head-on pass minimizes the IR signature of the OV-10 and presents a small silhouette. Maximum "g" turns should be avoided to maintain airspeed. Nose low turns help to maintain the best maneuvering airspeed of 200 KIAS. If the bandit is maneuvering for a head-on cannon shot, jink or crosstrack and keep the nose low. This will force the jet to bunt and readjust making a gunshot difficult. Continue to jink away from the tracking solution until the merge.

After the merge, make a careful search for the wingman. If there is a wingman, turn to engage as before. If not threatened by a wingman, bugout or lead turn to engage the bandit. The lead turn can be executed as soon as the attacker no longer poses a threat. (This is recognized when the bandit no longer maneuvers for position. Experience will aid in the OV-10 aircrew's perception of this.) The lead turn will be more effective if some angle off can be achieved early. If the reversal is done quickly, a retaliatory shot can be taken with an all-aspect missile. If possible, maintain 170 KIAS in the lead turn. If the bandit pitches up, this speed will be needed for a vertical AIM-9 shot. If the bandit turns in the horizontal, establish a lead turn to close for guns. Whenever possible, force the engagement to the lowest possible altitude. If onboard ordnance includes an all-aspect missile, position for an offensive head-on shot rather than defensive head-on pass.

7.6.3 Section Maneuvers. Mutual lookout within the section, succinct and timely communications, and sound employment of single aircraft maneuvering fundamentals are necessary for section ACM. Once engaged, the concept of mutual support provides the best lookout and weapon coverage of the flight. For this reason, excessive separation (more than 1 mile) should not occur. Conversely, flying too close together can cause double kill opportunities for the enemy. Counterflow, once engaged, can provide mutual support for a short period, but should not be used for any length of time. The opportunity for a retaliatory shot improves if the engaged OV-10 executes a timely maneuver forcing the attacker into a predictable maneuver (extension or pitchup). The free OV-10 can use an engaging turn to gain a missile shot advantage. Once the engaged (defensive) OV-10 has negated the threat and imposed some degree of predictability on the enemy, he should maneuver to enhance maintaining sight of the free enemy aircraft. Simultaneously, he should try to increase airspeed and maintain visual.

Note

> Simultaneous shots of missiles within the section should be avoided because of the limited number. Good communications is essential in preventing this.

While in spread or cruise formation, attacks can come from any direction. Early acquisition at the 6 o'clock position will allow for energy conserving engaging turns. Figure 7-11 is applicable to the section. A late tally at 6 o'clock will require energy using break turns. A sighting at 6 o'clock may require a defensive split turn as shown in Figure 7-12. Defensive maneuvers may require the loss of mutual support to the flight for short periods of time. It is always the tactical wingman's (free aircraft) responsibility to resume a spread position of mutual support. This can be accomplished once the enemy aircraft is no longer an immediate threat. If a missile is launched from enemy aircraft, countermeasures of expendables and aircraft maneuvering must be employed immediately.

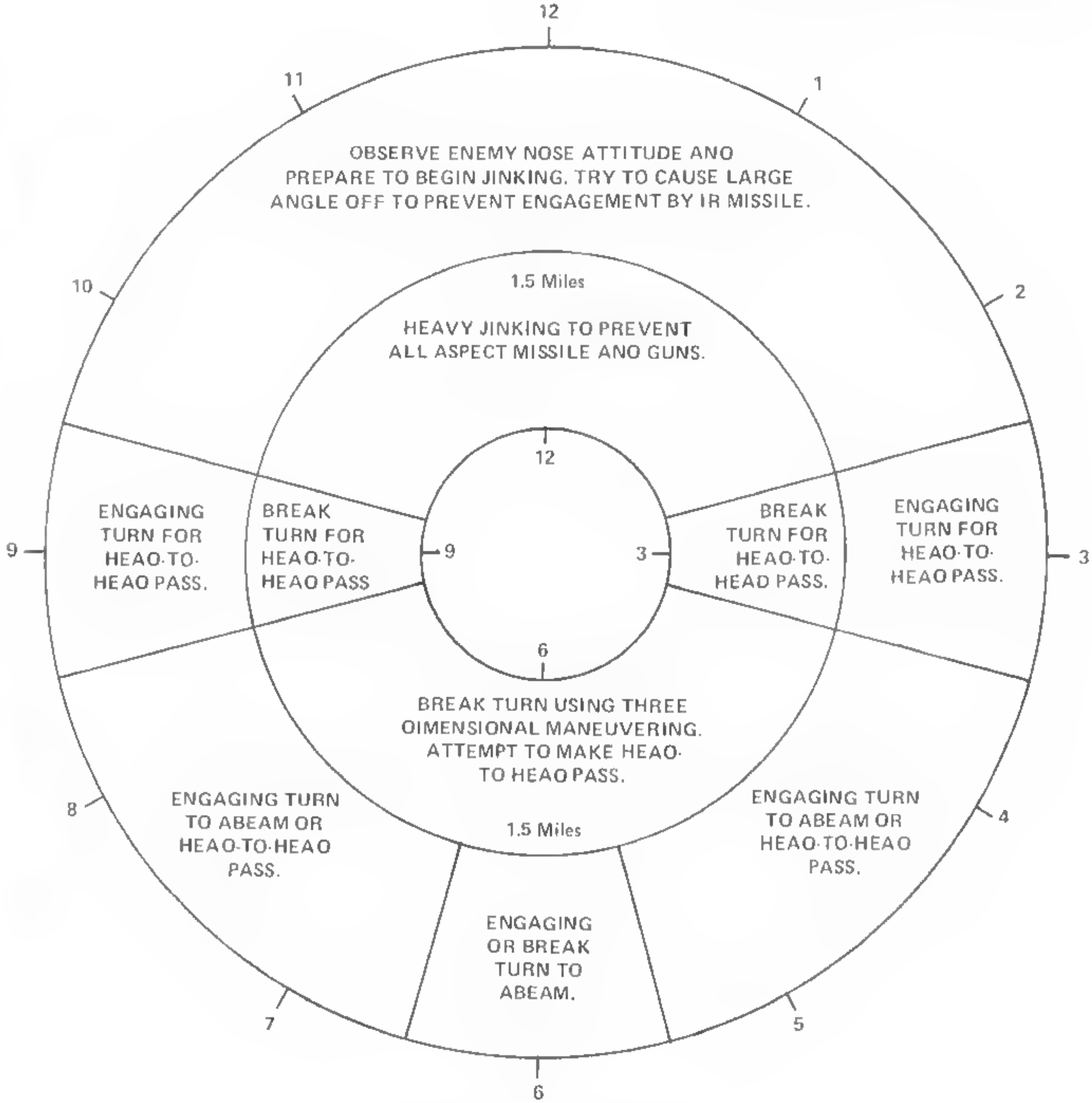


Figure 7-11. Maneuver Indicator

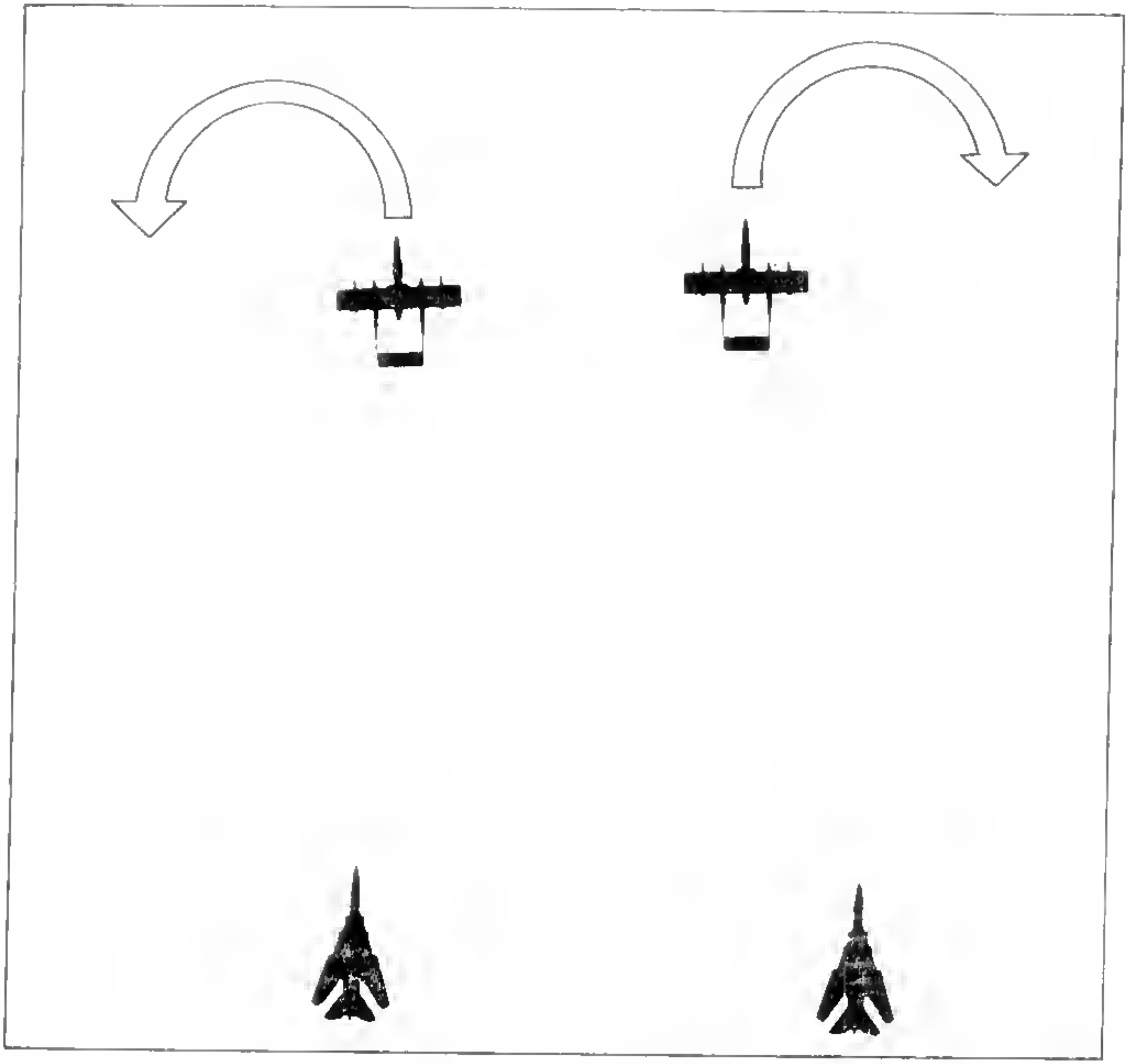


Figure 7-12. Defensive Split Trim

PART III

Aircraft Employment and Planning

CHAPTER 8

Mission Planning/Briefing

8.1 EMPLOYMENT FACTORS

For the benefit of planners who are not completely familiar with the aircraft, it should be noted that the OV-10 is primarily an observation aircraft with a limited air-to-ground ordnance capability.

8.1.1 Ordnance Capabilities. The tables containing the ordnance carrying capabilities and the operational limitations on various types of ordnance are presented in Appendix A.

8.1.2 Radius of Action — Cycle Times. Flight time can be determined as a function of the fuel load available based on the required mission configuration.

Cycle time on the deck is a function of total fuel and total ordnance load configuration. The OV-10 does not have a pressure refueling or hot refueling capability, and must be shut down for gravity refueling. Other factors affecting cycle time are EMCON conditions, number of aircraft involved, and possible maintenance.

8.1.3 Weather and Instrument Capabilities. Considering flight and navigational requirements, the OV-10 is an all-weather aircraft with the exception of most icing conditions. Instrument minimums will be established by the area commanders. Generally, the recovery minimums for shore bases are 200-foot ceilings and 1/2-mile visibility when ground controlled approach (GCA) is available. Rendezvous requires VFR at the rendezvous point. Ordnance delivery, while possible at ceilings and visibilities well below that required for high-performance CAS aircraft, is not feasible in IFR conditions. Weather minimums in the target area require consideration of ordnance and delivery maneuver, enemy capabilities, and targets.

8.2 METT-T FACTORS

The determination of which tactics and techniques to use for the best likelihood of mission accomplishment is based on careful analysis of the mission, enemy, troops, terrain (and weather), and time available (METT-T) considerations. Particular emphasis shall be placed on evaluating the nature and composition of the anticipated threat and its potential for adverse impact on the mission. The tactics and techniques selected for use shall be tailored to counter the threat environment and must be flexible, innovative, and nonpredictable in application. Detailed premission planning shall be conducted to determine flight tactics and techniques, to identify support requirements, and to coordinate the employment of fire support, EW support, and mission command and control. The guide illustrated in Figure 8-1 should be used for planning and briefing all tactical missions. Additionally, mission planning systems are available (TAMPS) to augment your planning/briefing. The following METT-T factors shall be analyzed during mission planning.

8.2.1 Mission. Conduct a review to ensure a thorough understanding of the scope, objectives, execution, command and control, and coordination details of the assigned mission.

8.2.2 Enemy. Carefully evaluate all available intelligence information to determine the disposition, order of battle, and capabilities of the enemy. These are the primary considerations in determining the anticipated threat level that will influence flight tactics.

8.2.3 Troops. The location of friendly troops, safe areas, and supporting unit capabilities should be considered. Plan to overfly safe areas whenever possible, and utilize supporting unit capabilities, such as fire support, radio relay, radar coverage, navigational aids, illumination, deceptive activity, and EW support. Location of friendly helicopter, attack, and fighter aircraft should be considered.

8.2.4 Terrain (and Weather). Evaluate the terrain in terms of physical characteristics to determine approach and retirement routes. If the situation permits and the element of surprise will not be compromised, a visual reconnaissance should be conducted, otherwise rely on a map and photographic study. In many instances, weather will be the determining factor as to the tactics and techniques to be employed. Weather should be evaluated in terms of its impact on both the friendly

scheme of maneuver and enemy capabilities. If not previously established, mission weather minimums shall be identified.

8.2.5 Time Available. To determine if there will be sufficient time for mission success, first evaluate the amount of time necessary to accomplish the mission and next add the transit time. These two factors added together during early mission planning will evaluate if the time allotted is sufficient to accomplish the task.

8.3 THREAT LEVELS

As antiair weapons become increasingly sophisticated, the second of the METT-T factors (enemy) assumes predominant significance. Improved survivability becomes the first critical step toward ensuring mission success. Before discussing the diverse missions of the aircraft, three levels of threat which affect aircraft tactics must be defined.

8.3.1 Low Threat. A threat environment that permits combat operations and support to proceed without prohibitive interference.

8.3.2 Medium Threat. A threat environment in which the specific aircraft performance and weapons systems capability allow acceptable exposure time to enemy air defenses.

8.3.3 High Threat. A threat environment created by a hostile force massing heavy combat power including integrated air defenses and EW capabilities which would seriously diminish the ability of the ACE to provide necessary air support. This environment might preclude immediate CAS.

8.4 SURVIVABILITY

While this manual primarily addresses tactics, survivability and mission completion in any threat environment are functions of two factors that can be influenced at the local level.

8.4.1 Equipment

1. Signature reduction increases the time required for acquiring and tracking the aircraft. Infrared signature reduction techniques include special engine exhausts and nonreflective canopies and paint.

2. Threat warning devices (radar warning receivers) allow aircrews to take evasive action or adapt their attack to counter the threat.

3. Countermeasures degrade enemy weapon system capabilities and include infrared and radar jammers, antiradiation missiles (ARM), and decoy expendables (chaff, smoke, and flares).

4. Vulnerability reduction includes such engineering features as redundant components, component shielding, armor protection, twin-engine configuration, and overall performance.

8.4.2 Tactics and Techniques

1. Teamwork can provide effective attrition of the threat, and compounds the problems which must be solved by the enemy's weapons systems. Examples of teamwork are: fire support coordination for suppression of AAA and SAM and use of EW support.

2. Terrain flying is used to remain below the threat envelope or behind terrain masking when the location of air-defense weapons is known with some certainty.

3. Night operations reduce the effectiveness of threat weapons requiring electro-optical acquisition or guidance.

4. Defensive maneuvering can be used to break lock or out-fly threat weapons and to make the gunner's solution more difficult.

5. Communications security increases the element of surprise, increasing enemy reaction time.

SITUATION

1. General
   a. Operation area
2. Friendly Forces
   a. Infantry (scheme of maneuver)
   b. Arty
   c. NGF
   d. Fixed wing
      (1) CAS
      (2) CAP
      (3) Escort
   e. Helicopter
   f. Fire support coordination measures
3. Enemy
   a. Operation area
   b. Ability to reinforce
   c. Ground threat location
   d. AAA threat
   e. SAM threat
   f. Air threat
   g. Expected movement
   h. EEIs
4. Local Populace
5. Applicable Maps and Charts
6. SERE
   a. Sanitize uniforms
   b. Passwords
   c. Barter kits/blood chits
   d. Selected area for evasion
   e. Designated area for rescue (DAR)
7. Electronic Warfare
   a. EMCON condition
   b. Deception/meaconing
   c. MIJI reporting
8. Encryption

WEATHER

1. Astronomical Data
2. RF Propogation
3. Current Weather
   a. Homeplate
   b. Operation area
4. Forecast Weather
   a. Operation area
   b. Homeplate
5. Alternate/Diverts
6. Night Brief.

Figure 8-1. Tactical Planning/Briefing Guide (Sheet 1 of 6)

MISSION

1. Primary/Secondary/Alternate
2. Handouts
   a. Kneeboard cards
   b. Maps/charts
   c. ATO
   d. ACEOI
3. Mission Statistics
   a. Mission Commander-Chain of Command
   b. Aircraft
   c. Callsigns
   d. Event numbers
   e. Aircraft configurations
   f. Ordnance
   g. Wt & Balance
   h. Takeoff data
   i. EW Suite
      (1) ALQ Setting
      (2) Chaff/flare program
      (3) APR-39
4. Mission Essential Equipment
   a. OV-10A/D
   b. Personnel
   c. Cameras
   d. FLIR Tape
   e. Laser plug glasses
   f. Binos
   g. NVGs
   h. Message drop bags
   i. T/O weapon
5. Go-No-Go criteria
6. Bump Plan
7. Mission Assets
   a. CAS A/C
      (1) Number/type aircraft
      (2) Callsign
      (3) Frequency
      (4) TOS
      (5) Ordnance
   b. Helicopter/gunships/escort/flight leader
      (1) Number/type aircraft
      (2) Callsign
      (3) Frequency
      (4) TOS
      (5) Ordnance
   c. Tanker
      (1) Callsign
      (2) Frequency
      (3) TOS

Figure 8-1. Tactical Planning/Briefing Guide (Sheet 2 of 6)

(4) Capacity

d. Artillery/NGF

(1) Call sign

(2) Frequency

(3) Target/fire/mission numbers

(4) Location

e. EW (EA-6B, etc.)

f. CAP

h. AWACS

8. Chain of Responsibility/Command

a. FSCC/ground FAC

(1) Callsign

(2) Frequency

(3) Location

b. TAC (A)

(1) Callsign

(2) Frequency

c. FAC (A) (single/multiple)

(1) Callsign

(2) Frequency

d. Airborne mission commander (AMC)/transport flight leader (TFL)

(1) Callsign

(2) Frequency

9. NBC Considerations.

EXECUTION

1. Ground

a. Manup

b. Turnup

c. Taxi time/plan/frequency

d. Crew coordination

2. Takeoff

a. Time

b. Rendezvous

c. Form flight characteristics

d. Crew coordination

3. TTO Procedures

a. Primary/alternate route

b. MEZ/FEZ

c. Formations/TAC form

d. Control measures (OPs, phase lines, etc.)

e. Airspeeds/altitudes

f. Inadvertant IMC

g. Weapons conditions

h. Penetration checklist

i. Probable point of first enemy contact

(1) SAM

Figure 8-1. Tactical Planning/Briefing Guide (Sheet 3 of 6)

(2) AAA
(3) Air
(4) Cap call
(5) Countermeasures/tactics
(6) Crew coordination

j. Comm procedures
(1) RIO
(2) Lost communications
(3) Code/pro/words
(4) Cap call
(5) Countermeasures/tactics
(6) Crew coordination

4. Minimum Operational Wx
5. Enroute Terrain
a. LAT
b. Mountains
c. Overwater
6. Helo Escort Considerations
a. Scatter plan
b. R/W escort plan
c. Escort flight leader's brief
7. Concurrent Operations
8. Target Area Tactics
a. TAC(A)
(1) Location
(2) TOS
(3) ATO
(4) Communications plan
(5) CP/IP/AP/HP
(6) CAS/helicopter routing
(7) FAC(A) boundaries
(8) ACAs/FSAs
(9) OAAW/SEAD mgr
(10) BDAs
(11) JTARs

b. FAC(A)
(1) Location
(2) TOS
(3) Communications plan
(4) Tactics (single/section)
(5) Target priorities
(6) CP/IP/AP/HP
(7) LGMs/PCG settings
(8) CAS routing
(9) FSC measures
(10) JTARs
(11) Supporting arms/SEAD
(12) NGF target number
(13) ACAs

Figure 8-1. Tactical Planning/Briefing Guide (Sheet 4 of 6)

c. VPR
   (1) TGT area
   (2) Camera settings/filters
   (3) Sun angle
d. CIFS/LZ suppression
   (1) Friendly positions
   (2) FSC measures
   (3) Weapons conditions
   (4) L-Hour
   (5) Supporting arms
   (6) LZ brief/reconnaissance
e. NOS/NVGs
   (1) Map study
   (2) Doppler settings
   (3) Recorder
   (4) Diurnal crossover
   (5) Illumination
f. FLIRCap/Viscap
   (1) Coverage
   (2) Weapons conditions
   (3) Patterns
   (4) Reload criteria
g. Ordnance delivery
   (1) Z diagrams
   (2) JMEMs
   (3) Sun angle
   (4) Hangfire/misfire/jettison

8. Rules of Engagement

9. RTF Procedures
   a. Pri/Alt routes
   b. Lame Duck procedures
   c. Formations
   d. Control measures
   e. Airspeeds/altitude
   f. Inadvertant IMC
   g. Weapons conditions
   h. Probable point last enemy contact
      (1) SAM
      (2) AAA
      (3) Air
      (4) CAP call
      (5) Countermeasures/tactics
      (6) Crew coordination
   i. Penetration checklist
   j. Communication procedures
      (1) RIO
      (2) Lost communications
      (3) Code/Pro words
      (4) Chattermark

Figure 8-1. Tactical Planning/Briefing Guide (Sheet 5 of 6)

(5) Visual signals
(6) Crew coordination

10. Enroute Terrain
    a. LAT
    b. Mountains
    c. Overwater
11. TRAP Considerations
12. Special Considerations.

ADMIN

1. Safety
2. Time Hack
3. Debrief Time/Location.

Figure 8-1. Tactical Planning/Briefing Guide (Sheet 6 of 6)

CHAPTER 9

Command and Control

9.1 INTRODUCTION

Tactical air operations, in support of an amphibious operation, are primarily directed towards gaining and maintaining air superiority, destroying/neutralizing enemy ground capabilities in the objective area, and responding to the immediate needs of the assault elements of the landing force. When the amphibious task force (ATF) enters the objective area, the commander of the amphibious task force (CATF) assumes responsibility for control of air operations (Figure 9-1).

9.2 ASSAULT PHASE

During the assault phase, air command and control will be exercised through the tactical air control center (TACC) afloat while coordinating supporting arms through the supporting arms coordination center (SACC). These agencies will be collocated within the amphibious task force. Prior to deployment ashore, Marine air command and control system (MACCS) personnel will be integrated with the control and coordination centers afloat to assist air operations, and to ensure a timely and efficient transition of control ashore. The tactical air control parties (TACP) will go ashore with the initial ground elements of the MAGTF and will be the first element of the MACCS to become operational ashore.

9.3 PHASING CONTROL ASHORE

In most amphibious operations involving a Marine air ground task force of Marine expeditionary brigade (MEB) or larger size, a prime consideration will be the early establishment ashore of air control facilities to provide increased surveillance, more rapid response, and an extension of the ATF's weapons control capabilities. Initially, elements of the MACCS ashore operate in a standby status, monitoring all air control circuits. After the MACCS is established and functional ashore and as the tactical air situation allows, the CATF may, upon recommendation of the commander of the landing force (CLF), pass all or portions of air control responsibility ashore to the MACCS agencies. In a continuing sequence, the agencies afloat are relieved of responsibility but continue to monitor the appropriate categories of control, participating when necessary. Regardless of the degree of participation, these afloat agencies will remain prepared to act as backup, or alternate, agencies until the termination of the amphibious operation.

9.4 TACTICAL AIR CONTROL PARTY (TACP)

To employ available aviation support effectively, the ground commander requires an air support planning and control element that also serves as a point of contact with supporting aviation activities. The TACP provides such an element. Composed of aviation officers and enlisted communication personnel, TACPs are organic to each infantry battalion, regimental headquarters, and the division headquarters, and ensure that each element receives its necessary support within the capabilities of available air resources.

9.4.1 Mission. The TACP advises the ground combat element commander on the employment of supporting aviation, establishes and maintains facilities for communication and liaison between supported ground units and appropriate air control agencies, and requests and controls air support missions.

9.4.2 Functions. As an element of the MACCS organic to the ground combat organization of the MAGTF, the TACP provides liaison and communications between the ground commander and appropriate air control agencies. It apprises the ground commanders of available air support and advises them on its employment, prepares and forwards air support requests as directed, and provides pertinent information to the air control agencies. In addition, the TACP at battalion level serves as a terminal control agency for CAS and integrates its employment with that of other supporting arms.

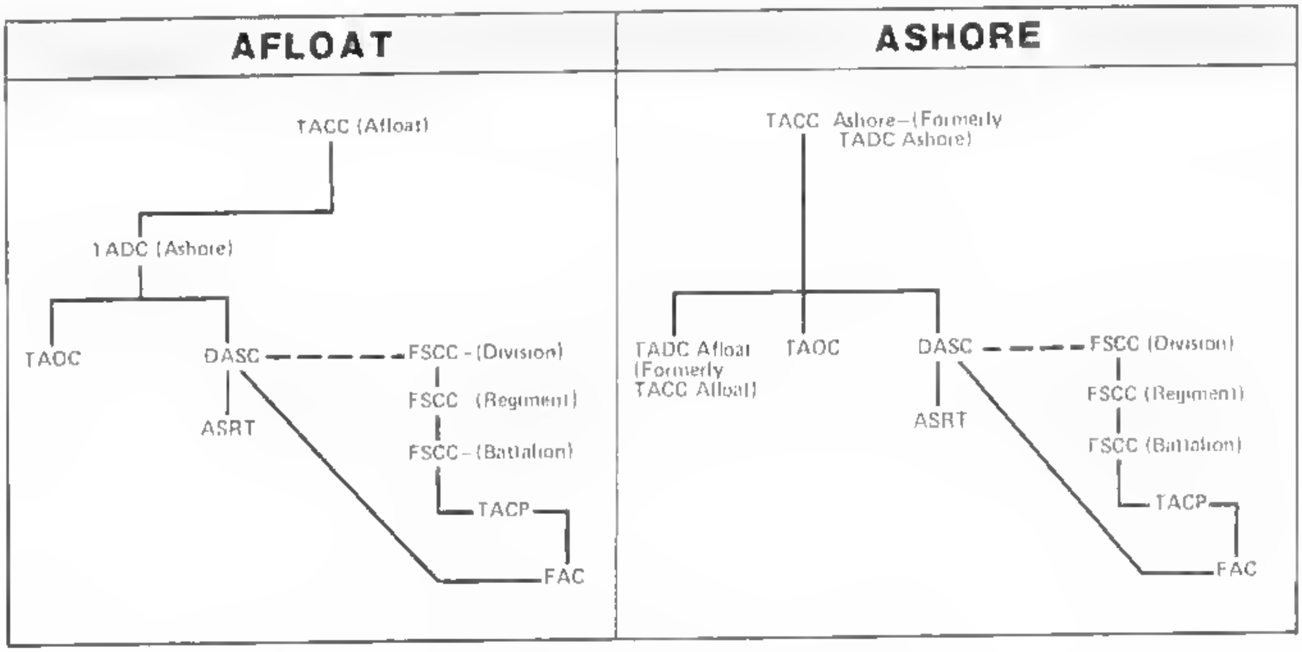


Figure 9-1. Command and Control

9.5 FIRE SUPPORT COORDINATION CENTER (FSCC)

The functions previously performed by the SACC afloat will be assumed by the landing force FSCC. The FSCC, located at the landing force (LF) headquarters and each subordinate level of command (regimental and battalion), is an agency with naval gunfire, artillery, and air unit representatives. The FSCC monitors, approves, and coordinates fire support requests for its area of responsibility. The senior level FSCC responsible for the coordination and control of all supporting arms will be colocated with the DASC when feasible.

9.6 MARINE AIR COMMAND AND CONTROL SYSTEM (MACCS)

The tactical air commander (TAC) must be provided with a centralized control system capable of dealing directly with individual aircraft flights. The concept of operations for the MACCS provides for centralized coordination and supervision of air operations at the highest level of the MAGTF, but at the same time facilitates decentralization of actual control authority to subordinate control agencies.

9.7 TACTICAL AIR COMMAND/ DIRECTION CENTER (TACC/TADC)

When the MACCS is essentially established ashore, but overall control is still retained by the CATF through the TACC (afloat), the CLF will exercise air control for his sector through a tactical air direction center (TADC). This holds true also if overall responsibility rests with a commander external to the MAGTF, (e.g., Air Force). When the MAGTF has overall responsibility for control of air operations in the objective area, the MAGTF commander establishes a tactical air command center (TACC). A TACC and TADC are essentially identical in facilities and capabilities, the difference being the amount of airspace that each is responsible and the scope of the assigned functions. The TACC/TADC is the senior MACCS functional agency. Within it, the supervision, coordination, and general control of all tactical air operations in the MAGTF area of responsibility are conducted. It also provides the Marine tactical air commander the facilities and means to direct and coordinate organic aviation with that of other services. To effectively fulfill its responsibility for air direction and command of tactical air operations, current intelligence information regarding pertinent aspects of the air and ground situation is collected by the TACC. The TACC is operated and maintained by personnel from the headquarters and headquarters squadron (H&HS) of the Marine air control group (MACG) and representatives of MAW operations and intelligence staff sections. Communication equipment for the TACC is provided and maintained by the Marine wing communication squadron (MWCS). The TACC exercises command and control of the entire MACCS through agencies both organic and nonorganic to the MACG. These agencies include the direct air support center (DASC) and air support radar teams (ASRTs) of the Marine air support squadron (MASS), one or

more tactical air operations centers (TAOCs) from the Marine air control squadrons (MACSs), if established the antiair operations center (AAOC) of the light anti-aircraft missile (LAAM) battalion, the battery control centers (BCCs) of the LAAM batteries, the weapons platoons of the low-altitude air defense (LAAD) battery, the tactical air control parties (TACPs) organic to infantry units, and detachments of the Marine air traffic control squadron (MATCS). The functional operation of the MACCS is generally divided into two major areas beneath the command and supervision of the TACC. These functional areas are antiair warfare and direct air support control.

9.8 TACTICAL AIR OPERATIONS CENTER (TAOC)

The TAOC exercises airspace management within its sector of responsibility, conducts positive radar control of tactical air assets, and controls and coordinates the air defense system as directed by the TACC.

9.8.1 Mission. The TAOC detects, identifies, and controls the intercept of hostile aircraft and missiles, and provides navigational assistance to friendly aircraft. It serves as the alternate TACC/TADC when directed.

9.8.2 Functions. In performing its assigned air defense and air control functions under the TACC/TADC, the TAOC recommends the deployment of assigned weapons and surveillance means, and the establishment of air defense sectors and subsectors of responsibility for itself and its subordinate elements. It detects and identifies all aircraft within its sector, maintains and disseminates appropriate information on the air situation, and provides an interface between adjacent and higher air defense agencies. It selects and assigns appropriate weapons, and controls their employment to counter enemy air threats. The TAOC coordinates and executes EMCON conditions in its assigned sector and directs the operations of satellite air defense agencies. Finally, it remains prepared to operate as a TACC/TADC for limited periods.

9.9 MARINE AIR TRAFFIC CONTROL SQUADRON (MATCS) DETACHMENTS

9.9.1 Mission. The MATCS detachments provide continuous, all-weather air traffic services for expeditionary airfields and remote area landing sites.

9.9.2 Functions. In functioning as the air traffic control agencies of the MACCS, MATCS detachments furnish radar approach, departure, and en route traffic control services within the AOA/ACS; provide airfield navigational aids; and provide precision radar approach services for airfield all-weather landings.

9.10 DIRECT AIR SUPPORT CENTER (DASC)

The DASC is the principal air control agency responsible for the direction of air operations directly supporting ground forces. It functions in a decentralized mode of operation, but is directly supervised by the TACC/TADC. It is normally the first major air control agency ashore and normally lands in the same category as the senior ground combat element FSCC. The DASC coordinates close air support strikes, assault support missions, and certain air reconnaissance missions. It affects the timely distribution of air assets assigned by the TACC for allocation to terminal control agencies including the FAC, FAC(A), and ASRT. Because detailed and continuous communications and coordination with the FSCC are essential to the effective integration of aviation with other supporting arms, the DASC collocates with that agency whenever practicable. The DASC, however, must be in a position where it can maintain effective communication with the necessary ground and aviation operating elements and control facilities. The DASC, equipped and operated by the Marine air support squadron (MASS), may displace by echelon to preserve operational continuity.

9.10.1 Mission. The mission of the DASC is to provide the means for processing direct air support requests (both fixed-wing and helicopter), to coordinate aircraft employment with that of other supporting arms, and to control aircraft operating within their assigned area of responsibility.

9.10.2 Functions. As the principal air control agency responsible for the conduct of direct air support operations, the DASC responds to requirements for preplanned and immediate support, in accordance with the ground combat situation and the degree of authority delegated by the TACC/TADC. It coordinates the execution of direct air support missions with the employment of other supporting arms, referring conflicts in supporting arms activity to the appropriate FSCC for resolution. For purposes of adjusting the provision of air support to the tactical requirements, and for the dissemination of pertinent operational information, the DASC serves as the point of contact for supporting aircrews and user agencies of all echelons of the supported ground combat organization. It receives, maintains, and disseminates ground and air intelligence as necessary to provide the requisite coordination with aircrews, ground elements and control agencies, both internal and external to the MAGTF. It assigns support aircraft to terminal control agencies, providing general routes of aircraft

approach and retirement and other advisory information to assist in the conduct of safe flight. The DASC coordinates the movement and identification of friendly aircraft under its control with the TAOC for air defense purposes.

9.11 AIR SUPPORT RADAR TEAM (ASRT)

The ASRT is a terminal air support control agency subordinate to the DASC which provides precision radar tracking and positioning of aircraft in all weather and visibility conditions. The ASRT employs a radar course directing central (RCDC) which consists of a precision radar and associated computer equipment designed to accurately position aircraft without visual reference to the Earth's surface. Aircraft can be guided to a point in space from which released bombs impact on a predetermined target. This is accomplished by using radar-derived positional information and manually inserted target position information, wind data, ballistics data based on the type of ordnance being used, and speed and altitude of the aircraft and radar antenna altitude. To accurately compute this radar positional information, the ASRT must be positioned by an accurate land survey. There are three ASRTs organic to the MASS under the operational control of the DASC.

9.11.1 Mission. The mission of the ASRT is to provide day/night all-weather precision control of aircraft operating in support of MAGTF operations.

9.11.2 Functions. In providing all-weather precision control of direct air support aircraft, the ASRT receives target information and computes the necessary data for the conduct of medium and high-altitude level bombing. For navigational assistance to low altitude aircraft, the ASRT computes the necessary data to direct the aircraft to the required control point, such as an initial point or pop-up point. In addition to providing control of bombing missions, the ASRT is capable of positioning aircraft for the performance of other combat support and assault support tasks (e.g., paradrops, flare drops, aerial photography, LZ positioning, or limited GCAs).

9.12 AIRBORNE COORDINATION AND CONTROL AGENCIES

In the execution of tactical air operations, particularly direct air support, many situations arise in which aircraft coordination or control through a ground agency is not available, not feasible because of terrain restrictions, or not adaptable to a high activity/multi-aircraft situation. These situations require that terminal coordination or control be conducted through an appropriately equipped airborne platform. The MACCS has the capability to handle such situations by utilizing airborne coordination and control agencies such as the tactical air coordinator airborne (TAC(A)), the helicopter coordinator airborne (HC(A)), or the forward air controller airborne (FAC(A)). These airborne agencies are positioned in proximity to the specific geographic area of concern; e.g., a landing zone or an enemy target. They perform the overall visual observation of air and ground activity and coordinate or control activity from a relatively detached vantage point. Equipped with adequate communications, they maintain simultaneous contact with the ground units, the supporting aircraft, and the DASC, serving as a point of coordination between them. Airborne coordination and control agencies make significant contributions to the flexibility and effectiveness of the MACCS. The following paragraphs discuss these agencies in greater detail.

9.12.1 Tactical Air Coordinator Airborne (TAC(A)). The TAC(A) is an experienced aviator airborne in the area of operations in a helicopter or fixed-wing aircraft. His primary responsibility is to coordinate and direct the activities of aircraft assigned to him and to report to the appropriate ground and air agencies in his area of responsibility. The coordination function may involve the handling of a variety of types and numbers of aircraft or integrating air activity between helicopters and fixed-wing aircraft, as in a helicopterborne assault, landing zone preparation, or resupply. The TAC(A) must have a thorough understanding of supporting arms coordination and artillery/naval gunfire spotting procedures. He is employed when directed by the ACE.

9.12.2 Helicopter Coordinator Airborne (HC(A)). The HC(A) assists the DASC in the coordination and control of helicopters. The HC(A) may be assigned responsibility for certain command aspects of the helicopterborne assault, and further coordinates with the TAC(A) for activity in the vicinity of the landing zone. During the initial phase of a helicopterborne assault involving substantial distances, two separate HC(A)s may be designated, one for control and coordination of helicopters and fixed-wing activity near the LZ, and the other to assist in control of helicopter movement along approach and retirement corridors.

9.12.3 Forward Air Controller Airborne (FAC(A)). The FAC(A) is an air controller airborne over the area of operations in a helicopter or fixed-wing aircraft. The primary function of the FAC(A) is the detection and destruction of enemy targets. They may be close air support or deep air support targets. The FAC(A) may be assigned directly to support a given

ground unit or he may be assigned as subordinate to a TAC(A) to provide air control as required on various types of operations. He should have a working knowledge of fire support coordination procedures, visual reconnaissance, and artillery/naval gunfire spotting techniques. The FAC(A) will be employed when requested by the GCE.

19.12.4 Direct Air Support Center (Airborne) (DASC (A)). The DASC (A) will normally consist of the AN/UYQ-3A DASC system mounted in a KC-130 aircraft in support of MEB or larger sized operations. The DASC(A) may supplement an existing ground DASC's capability, or provide an independent facility. Air superiority is essential if a DASC(A) is to be employed. The DASC(A) system contains all those essential communications capabilities normally associated with a ground DASC. Operational situations in which the DASC(A) could be employed are listed below:

1. Extended overland displacement.

2. Supplementing coverage of the primary DASC while it is displaced or degraded.

3. Operations in geographic areas where terrain characteristics adversely affect DASC communications.

4. Amphibious operations to aid in phasing control ashore from the NTACS to the DASC.

5. Split sector operations while control is afloat or ashore.

6. Other missions as directed by the MAGTF commander.

9.12.5 Airborne Warning and Control System (AWACS). The E-3 AWACS is a U.S. Air Force airborne early warning system incorporated into a modified Boeing 707 airframe. The aircraft has an aerial refueling capability and may remain airborne from 9 to 24 hours depending upon crew configuration and mission requirements. Some of the more common missions include sector surveillance and control, weapons control, and/or a platform from which a battle-staff could operate. In Marine Corps terminology, it would closely resemble performing all of the functions of a TAOC if it were mounted in an aircraft. The E-3 has on board a total 14 UHF radios, as well as HF and VHF capabilities. It also incorporates three types of digital data communications: TADIL-A, TADIL-C, and JTIDS. TADIL-A is the tactical digital information link that allows them to transmit an air picture and operational information on secure UHF and/or HF. The E-3 radar equipment is housed in the ROTODOME mounted above the aircraft. It has two separate radar modes, pulse doppler radar, and pulse radar, that allow it to track aircraft at ranges of up to 300 nm. The radar is also resistant to electronic countermeasures because of its narrow main beam and low side lobes.

9.12.6 Airborne Battlefield Command Control Center (ABCCC). The ABCCC is a U.S. Air Force automated command and control facility that is carried in a modified C-130 aircraft. This facility is essentially a capsule, mounted in the aircraft that contains crew stations, computer generated displays, and mission planning and control equipment. It is designed to enable a headquarters command to maintain control of joint air, sea and land forces in forward mission areas. It exercises procedural control over these forces using satellite, UHF, VHF, and HF communications. The aircraft and crew configurations are designed to accommodate 14 hours on-station time. The aircraft is multimission capable and can perform or coordinate the following tasks: tactical air direction, battlefield information analysis, close air support, search and rescue operations, drug interdictions, and others. In its function, it most closely resembles a combined tactical air command center (TACC) and direct air support center (DASC), mounted in an aircraft.

9.13 TAC(A)/FAC(A) RELATIONSHIPS

The TAC(A) and FAC(A) may operate from several different types of aircraft, but this should not detract from the understanding of their roles and relationship to one another or to the ground and air command and control system. In fact, because of the importance of their roles and the critical decision making of these two agencies, it is imperative that they have a broad understanding of how the command and control system works.

The FAC(A) should make the earliest possible contact with the TAC(A) if one is assigned. This may in fact have to be done while on station or approaching the assigned area in many instances, especially if the TAC(A) is launching from another base or is already on station. The items discussed between the two will include mission unique frequencies, call signs, rendezvous points to reestablish lost communications, operating areas of the two, air control points to be used, any update on the air threat, and any strike aircraft previously requested for the ground unit with which the FAC(A) may be involved. The TAC(A) will keep the FAC(A) updated on all information pertinent to this mission throughout his time on station. The FAC(A) will maintain communications during his time on station with the unit supported and will also

keep him abreast of the information above relayed from the TAC(A). His relationship with the TAC(A) is one of partnership rather than subordinate agency to superior agency.

The TAC(A) normally works in close relationship with the DASC and is in fact considered to be an extension of the DASC. This relationship causes the TAC(A) to be intimately familiar with the intended air effort throughout his period of assignment. He must be aware of all air that has been requested, either planned or immediate, DASC location and nets available for entry into the DASC, and any FSCC with which he may have to communicate for coordination purposes if the DASC is unable to do so. He must maintain continuous communication with assigned FAC(A)s, FACs and DASC to ensure an unbroken exchange of information and requests. He must manage the airspace assigned to ensure safety of strike flights and a smooth hand over to terminal controllers. He will control the movements and assignments of FAC(A)s consistent with the ground commander's needs (normally made known to the TAC(A) through communications with the DASC and by implicating the appropriate FSCC).

9.14 COMMUNICATIONS NETS

The FAC(A) and TAC(A) should be thoroughly familiar with communications nets as discussed in the following paragraphs.

9.14.1 Tactical Air Direction Net (TAD). The TAD net provides a means for the direction of aircraft in the conduct of close air support missions and for the DASC to brief support aircraft on target information, or assignment to the TACP, FAC(A), etc. Multiple TAD nets are required and are assigned to major air control agencies. Agencies composing the net are the DASC, FAC(A), TAC(A), TACP, ASRT, and assigned strike aircraft. (Normally UHF, but there may be VHF/FM alternates assigned.)

9.14.2 Tactical Air Request Net (TAR). The TAR net provides a means for forward ground combat units to request immediate air support from the DASC. Intermediate ground combat echelons (FSCCs) monitor this net and may modify, disapprove, or approve a specific request. The DASC uses the net to brief the requesting unit on the details of the mission. Multiple TARs may be required. (Normally HF, but can be VHF/FM alternates designated. Provides an alternate means for the FAC(A) and TAC(A) to communicate with the TACP, air officer, or appropriate FSCC.)

9.14.3 Tactical Air Observation Net (TAO). The TAO net provides a means for the tactical air observer to report action observed, information on the enemy situation, and the progress of friendly forces. This net is composed of TACC/TADC, the DASC as required, observation aircraft, and ground units as required.

9.14.4 Tactical Air Traffic Control Net (TATC). Provides a means for the TACC/TADC, TAOC, and DASC to exercise control of all tactical aircraft in the objective area. Types of information passed over this net include aircraft reports of launches by mission number, clearing aircraft to their assigned control agencies, diverting aircraft as necessary, and aircraft completed mission reports prior to landing. Multiple TATC nets are required with the TACC/TADC, TAOC, and DASC each having its own net (UHF).

9.14.5 Infantry Regiment and Battalion Tactical Net. The infantry regiment and battalion tactical net provides a means for the commander to exercise control of subordinate units. It is manned by regiment and battalion headquarters, infantry battalions and companies as appropriate, and supporting and attached units as appropriate, (normally VHF/FM.)

9.14.6 Naval Gunfire Ground Spot Net. The naval gunfire ground spot net provides a means to control a ship's gunfire support. This net provides communications between the naval gunfire spotter, the fire support ships, and the battalion naval gunfire liaison officer for conducting fire missions against enemy targets. It may be multiple networks assigned, dependent upon the number of units requiring NGF support. (Normally HF and provides an alternate means for the OV-10 aircrew to communicate with ground forces.)

9.14.7 Tactical Air Control Party Local Net. The tactical air control party local net provides a means for coordination between the air liaison officer and the forward air controllers. This net is manned by the air liaison officer and FAC teams. (An FM net and provides an alternate means for the OV-10 aircrew to communicate with ground forces.)

9.14.8 Artillery Conduct of Fire Net. The artillery conduct of fire net provides a means for forward observers to request and adjust artillery fire. There can be as many as four COF nets in one direct support artillery battalion. These nets are manned and monitored by the battalion or battery fire direction centers, forward observers, and artillery liaison officers (FSCCs). (VHF/FM and provides an alternate means for the OV-10 aircrew to communicate with ground forces.)

9.14.9 Artillery Air Spot Net. The artillery air spot net provides observation aircraft a means to transmit target information to artillery units and to adjust fires. It

is manned and monitored by artillery battalions, batteries, and artillery liaison officers as appropriate. (VHF/FM and provides an alternate means for the OV-10 aircrew to communicate to ground forces.)

9.14.10 Direct Air Support Net (DAS). The DAS net provides a means for the DASC to request direct air support from the TACC. Additionally, information pertaining to aircraft stationing, fuel, and ordnance status, progress of close air support mission, etc., may be passed over this net. It is composed of TACC/TADC and the DASC. (HF and could be entered by the OV-10 aircrew if the situation warranted to process air requests, DASC losses communications with TACC, jamming, DASC rendered inoperable by enemy fire, and so forth.)

9.15 ACEOI

The TAC(A) and FAC(A) should launch with information from automated communications and electronics operating instructions containing as a minimum, the nets described in the above paragraph for every unit in the AOA. This will permit services to not just one unit but to any unit, regardless of tactical situation changes.

CHAPTER 10

Aircraft Missions

10.1 INTRODUCTION

The mission of the Marine observation squadron (VMO) is to conduct day/night observation and reconnaissance, air support operations, supporting arms coordination and such other air operations as may be directed. This includes the following tasks:

1. Conduct visual, photographic, and multisensor aerial reconnaissance and observation.

2. Coordinate and control offensive air support and supporting arms, to include airborne tactical air controller (TAC(A)), airborne forward air controller (FAC(A)), laser designation, and aerial spotting functions.

3. Conduct helicopter escort, antihelicopter operations, and close-in fire support in support of assault support operations.

4. Conduct air defense operations within the capability of assigned aircraft.

5. Maintain the capability to operate under conditions of reduced visibility and darkness.

6. Maintain the capability to deploy and operate from forward sites, advanced bases, expeditionary airfields, and compatible naval shipping.

7. Conduct paradrops and emergency aerial resupply operations.

8. Maintain the capability to augment search and rescue operations.

10. Perform organizational level maintenance on assigned aircraft and associated equipment.

11. Conduct other such operations as may be required within the capabilities of assigned aircraft.

10.2 VISUAL RECONNAISSANCE

Visual reconnaissance (VR) is generally described as airborne activity primarily for detection and gathering of timely intelligence that will aid in the conduct of military operations. The pilot and aerial observer must be familiar with the enemy and friendly situation, weather, terrain, and areas where enemy fire has been reported so as to be properly prepared for the conduct of the flight. A thorough briefing with the unit intelligence section will provide this information and greatly improve the overall intelligence gathering effort.

The object of reconnaissance is to achieve a wide area coverage at an altitude that gives acceptable definition of detail on the surface while remaining out of small arms fire as much as possible. An altitude of 1,200 to 1,500 feet above ground level (AGL) and 120 to 150 knots is recommended as being most profitable for VR if the environment permits. The pattern over the ground is influenced by terrain, lighting, weather, and enemy situation; however, extreme care should be taken in even the most permissive environment to avoid continued, repetitive patterns. Such devices as random reversals, figure eights, and apparent disinterest will make tracking the OV-10 more difficult. When closer observation of a point of interest is necessary, a low-altitude, high-speed jinking run will afford the best protection. VR missions are divided into two broad categories, area and point reconnaissance. Area reconnaissance is utilized to detect enemy movement and daily changes in the topography or routine of a region's or unit's area of responsibility, providing the commander with an early warning of enemy intentions and identifying specific target areas for further observation.

The point reconnaissance mission is directed toward a specific sector never larger than a few grid squares and frequently centered around a single grid coordinate. Reconnaissance of this nature is initiated to provide unit commanders with information on the

enemy and terrain that may have an immediate effect on his unit.

VR missions in the OV-10 aircraft are usually conducted for battalion company- sized units to provide these units with an expeditious source of intelligence information. A pilot and aerial observer will be assigned to support a particular unit until their requirements are satisfied or a higher priority mission is assigned. Whether assigned an area or point reconnaissance mission, the principles remain the same. The simplest intelligence gained through visual reconnaissance is an actual enemy sighting. Since the enemy usually tries to prevent this whenever possible, most intelligence gained through VR requires interpretation to determine its actual relationship to the combat situation. Sightings in some areas may be perfectly normal, while the same sightings in a different location may indicate increased enemy activity. For this reason, it is highly desirable that pilots and aerial observers be assigned specific areas of responsibility on a continuing basis so that they will be familiar with the normal routine of the area and more readily detect significant sightings. The pilot and aerial observer should become familiar with all urban activities in their area. Observation should include not only primary lines of communication but also the surrounding area.

VR in the jungle is extremely difficult. Although the thick jungle canopy prevents VR over vast areas, much of it is broken up by new or old farmlands, natural meadows, or areas where the trees and shrubs are low enough to observe the ground. These areas should be observed for signs of trail usage, new farmlands, people, structures, and water holes; all of which may indicate unusual activity in the area.

Rivers and streams in the jungle are also very important and should be observed closely. The presence of cables, rafts, footbridges, or prepared fords across a waterway may be an indication of enemy activity and should be recorded. The prepared ford (underwater bridge) is difficult to detect from the air and requires close observation. It can normally be detected by the ripple caused in the water; however, it should not be confused with the many dams common to the area that cause a similar water disturbance. Slight differences in riverbed color tone may also indicate an underwater bridge.

Foot traffic across streams or lakes causes a muddy disturbance that remains for a long period of time and can often lead to the discovery of hidden trails. Direction of movement may be indicated by one bank of the stream appearing darker in color than the opposite bank due to water deposited upon exit. Significant sightings observed during the mission shall be reported by the most expeditions means available, such as radio or message drop.

Each mission shall be thoroughly debriefed upon completion. This is extremely important since intelligence information collected during the flight is disseminated to higher commands. An effective debriefing requires a concentrated effort by both the pilot and the aerial observer to provide a detailed and accurate report to ensure all intelligence information is recorded and distributed. Although it may seem insignificant by itself, the sighting may assume importance when combined with other intelligence information. Normal equipment for VR missions should include a hand-held camera and optical viewing device (binoculars or stabilized monocular) and appropriate maps or aerial photos.

10.2.1 Types of VR

10.2.1.1 Low Threat VR. Local VR is accomplished by a single OV-10 in reasonably close proximity to friendly forces to provide that unit commander with timely intelligence within his area of responsibility.

The deep VR mission is flown at considerable distances from friendly positions. It is most prudently accomplished by two aircraft. The deep VR tactical formation is flown with the wingman stepped up 2,000 to 3,000 feet, and between the 3 to 5 o'clock and 7 to 9 o'clock positions from the leader. The low aircraft covers the area assigned in a manner consistent with VR techniques, plotting, and photographing significant sightings. The high, covering aircraft should keep the area in view over which the low aircraft is flying, continuously maintaining a position that permits a roll-in for suppressive fire in the event the low aircraft is taken under fire. It is emphasized that the mission of deep VR does not include seeking destruction of the enemy with organic weapons. Experience has shown that if other than passive VR techniques are employed with lucrative targets, enemy fire can be expected.

When intelligence indicates, enemy weapons will permit VR only at altitudes above 10,000 feet. Ground units should not expect as detailed information as can be obtained from lower altitudes. Use of binoculars and STEDI-I monoculars will assist in improving the detail of the reconnaissance from higher altitudes.

Proper crew coordination is essential. At these altitudes the aircraft is extremely vulnerable to attack by both fighter aircraft and larger surface weapons. One crewman must always be searching for these threats while the other completes the reconnaissance. The presence of a supporting aircraft at higher altitude (out of range of the surface threat) may allow the recon-

naissance aircraft to operate at a lower altitude by alerting him to surface weapon firings. The feasibility of the lower altitude depends on the nature of the threat in the immediate area.

10.2.1.2 High Threat VR. VR in a high-threat area must be accomplished at terrain flying altitudes, maintaining terrain masking from the known threat. A proper scan pattern (Figure 10-1) is essential at these altitudes and requires conscious use of peripheral vision. When flying low level along a preplanned route, elapsed time from a known checkpoint may be the easiest way to pinpoint the location of an observation. Depending on the threat, a pop-up maneuver to observe a larger area or to take a photograph may be feasible.

10.2.1.3 VR in Counter-Insurgency Operations. Doctrine for aerial surveillance and reconnaissance in insurgency operations is the same doctrine as applied to other types of warfare. Methods and techniques of employment remain the same, only varying in their application to the scope of surveillance and reconnaissance requirements unique to the particular insurgency situation and environment. However, the difficulty encountered in intelligence acquisition is greatly increased because of the nature of insurgency concepts, force structure, tactics, and practices.

The insurgent forces in the areas of operation do not present or generate those indications of their existence that are easily detectable or identifiable. Conversely, aerial surveillance/reconnaisance aircraft operating in this environment have greater flexibility in tactics because of the lack of significant enemy air defense systems. This differs considerably from the relative difficulty in surviving in a sophisticated hostile air defense environment. The success of aerial surveillance and reconnaissance efforts in counter-insurgency operations will be dependent on the level of experience of the aircrews and interpreters in the area of operations.

10.2.1.3.1 Special Considerations. Counterinsurgent operations encompass the terrain of an entire country with the possible attendant problems of long sea coasts and ill-defined international boundaries. In addition, the terrain on which the enemy organizes his base areas may be remote, sparsely populated, and characterized by extreme terrain configurations and poor lines of communication. His security practices and ability to blend into existing cultural activities and features make his areas of habitation difficult to identify, both in the host country and in the sanctuary areas.

The problem is to formulate realistic indicators of enemy activity in all local environments. This must be accomplished if enemy activity is to be separated from normal civilian activity.

The prerequisite to success is a thorough understanding of the total sum of the natural and human factors involved in the area of operations. These factors include detailed knowledge of enemy forces and methods of operation, coupled with physical geography and cultural aspects as well as the sociological and economical aspects of rural and urban configurations and activities, to include agriculture, industry, transportation, and communications.

Insurgents can be detected through indirect, as well as direct, evidence of their presence. Direct evidence normally is difficult to gather in country-insurgency operations. Such evidence includes uniforms, equipment, military type vehicles, deliberate field fortifications, logistical facilities, and large troop movements. Indirect evidence of insurgent presence are most probably the indicators that will be first discovered. Examples of indirect evidence are:

1. Ostensible civilian activity in isolated areas or in areas where activity normally has not been observed.

2. Unexplained increase in the dwelling density of village or hamlet

3. Built-up areas not shown on official maps or which are detected as a result of comparative photography of the area.

4. Unexplained movement of local inhabitants from one location to another or across international boundaries.

5. Isolated open areas being prepared for, or under cultivation with food crops or small areas of forest being cleared of underbrush and thick foliage for no apparent reason.

6. Logging, charcoal, and other rural-type production in areas previously unworked or not easily accessible to people of the area.

7. Roads, trails, and footpaths that are inconsistent with population centers and the agricultural practices of the area.

8. Other unexplained disturbance to the normal surface characteristics of the area.

9. Fires in remote areas or burned out areas that have been caused by local ground clearing operations or indigenous cultivation.

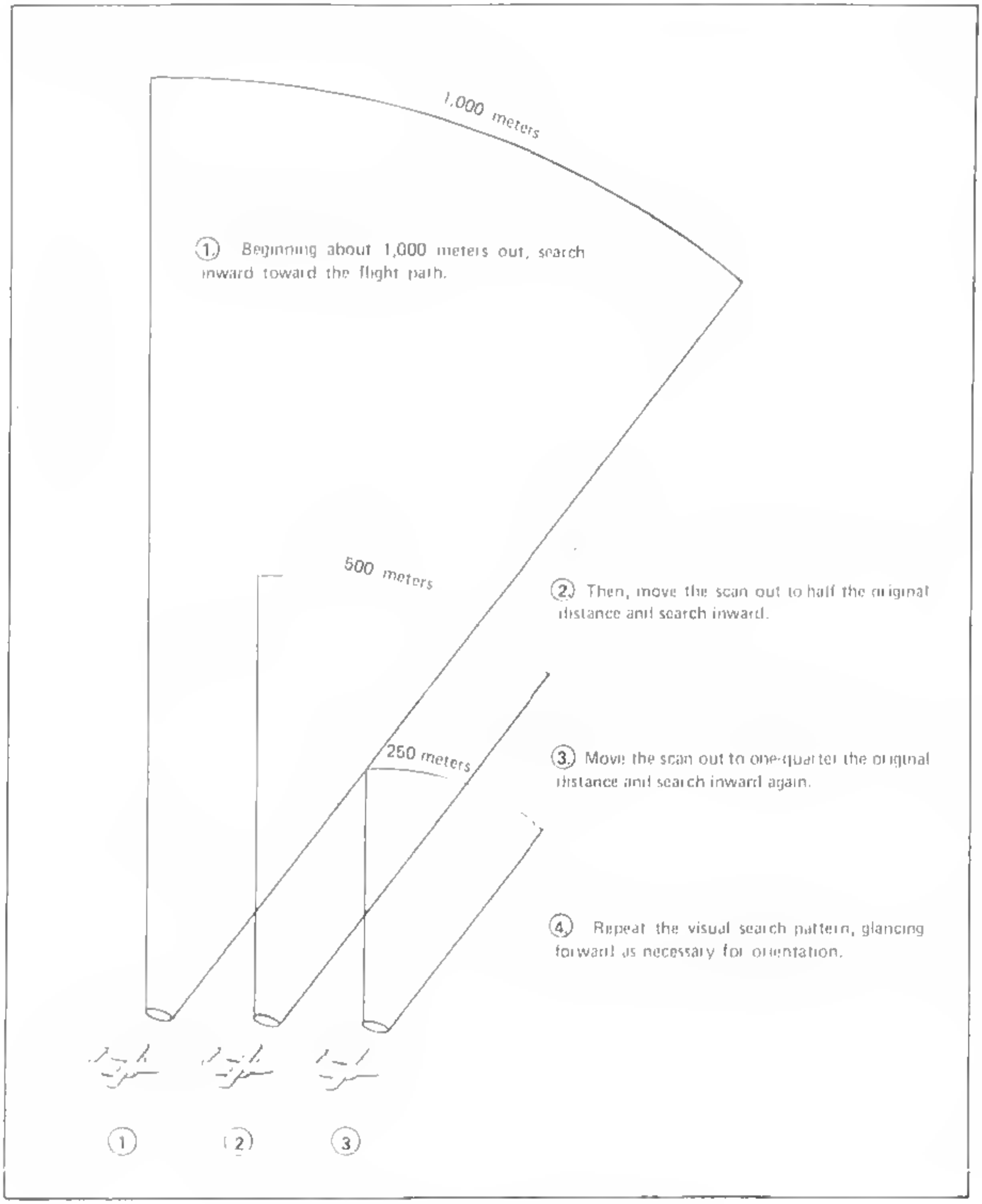


Figure 10-1. Typical Visual Search Pattern

10. Fish nets located in isolated areas or areas previously unfished.

11. Abnormal increase in traffic on established roads or waterways.

12. Beasts of burden grazing in uninhabited areas as well as the presence of edible livestock in these areas.

13. Any unidentified or suspicious activity detected by IR, radar, or other sensory devices at night or during bad weather.

Unclassified and classified area handbooks held by the S-2/G-2 should be studied prior to assignment in the host country to determine normal lifestyles. In addition, pilot/observer teams should be assigned to designated surveillance areas. After approximately ten flights in an assigned area, the team will begin to be familiar with their area to the point that deviation from normal activities will be apparent.

10.2.2 VR Tasks

10.2.2.1 Road Reconnaissance Report

Date: ___________

1. Requesting Unit:______________________________
2. DTG of Mission:______________________________
3. Map:
   a. Name:______________________________
   b. Scale:______________________________
   c. Sheet no:______________________________
4. Coordinates:

   From: ______________________________ To: ______________________________
5. Direction of road (Circle one):

   a. N-S   b. NE-SW   c. E-W   d. NW-SE
6. No. of lanes:____________________
7. Width of roadway (feet): ____________________
8. Length of roadway (statute miles):____________________
9. Alignment (Circle one):
   a. Flat gradients and easy curves
   b. Steep gradients
   c. Sharp curves
   d. Steep gradients and sharp curves
10. Drainage (Circle one):
    a. Adequate ditches, crown, with adequate culvers in good condition.
    b. Inadequate ditch, crown, or culverts (list location of inadequate conditions under remarks)
11. Type of surface (Circle one):

a. Concrete	b. Asphalt	c. Brick
d. Crushed rock or coral.	e. Stone	f. Macadam
g. Gravel	h. Natural soil, clay, shell or cinders	

i. Other (describe): ____________________

12. Surface conditions (Circle one):

a. Free of craters, bumps, ruts

b. Cratered, bumpy ruts

13. Turn-a-rounds (single lane road only):

a. Nature: ____________________

b. Location: ____________________

14. Obstructions:

a. Overhead clearance less than 14 feet such as tunnels, bridges, overhead wires, etc.

(1) Description: ____________________

(2) Location: ____________________

15. Bridges, fords, ferries (attach report): ____________________

16. Area under repair or needing repair:

a. Reason: ____________________

b. Location: ____________________

17. Repair materials available:

a. Type: ____________________

b. Locations: ____________________

18. Remarks: ____________________

Air Observer ____________________

Unit ____________________

10.2.2.2 Railroad Reconnaissance Report

1. Requesting Unit: ______________________________
2. DTG of Mission: ______________________________
3. Map: ____
4. Coordinates:

   From: ____________________________ To: ____________________________

5. Direction of tracks (Circle one):

   A. N-S B. E-W C. NE-SW D. NW-SE

6. Gauge of track (Circle one):

   a. Narrow b. Standard

7. Number of tracks: _________________________
8. Condition of tracks (Circle one):

   a. Excellent b. Good c. Fair d. Poor

9. Road bed material (Circle one):

   a. Crushed rock b. Other (specify): ___________________________

10. Condition of road bed (Circle one):

    a. Excellent b. Good c. Fair d. Poor

11. Bridges (coordinates for center of bridge): _____________________________
12. Switches (coordinates): ____
13. Side tracks (coordinates): ____
14. Depots (locations):

    From: ____________________________ To: ____________________________

15. Warehouse (locations and condition): ______________________________
16. Marshaling yards (location and condition): _________________________
17. Refueling facilities (location and condition): ______________________
18. Remarks: ____

10.2.2.3 Bridge Reconnaissance Report

1. Requesting unit: ____________________
2. DTG of mission: ____________________
3. Map: ____________________
   a. Name : ____________________
   b. Scale : ____________________
   c. Sheet no.: ____________________
4. Type of bridge (Circle one):
   a. Highway b. Railroad c. Foot
5. Coordinates (at center): ____________________
6. Direction of bridge (Circle one):
   a. N-S b. E-W c. NE-SW d. NW-SE
7. Crossing (name of geographical feature): ____________________
8. Location from nearest town:
   a. Distance: ____________________
   b. Direction: ____________________
   c. Town: ____________________
9. Roadway width: ____________________
10. Bridge width: ____________________
11. Height of handrail: ____________________
12. Length of bridge: ____________________
13. Type of bridge (Circle one):
    a. Truss b. Draw c. Arch
    d. Wooden stringer e. Suspension f. Concrete slab
    g. Floating h. Swing i. Steel stringer
14. Number of spans:
15. Length of spans:

16. Type of spans (Circle one):

    a. Simple b. Continuous

17. Condition of superstructure (Circle one):

    a. Excellent b. Good c. Fair d. Poor

18. Material intermediate support is constructed of (Circle one):

    a. Wood b. Steel c. Concrete

19. Intermediate supports have protecting fenders (Circle one):

    a. Yes b. No

20. Condition of superstructure (Circle one):

    a. Excellent b. Good c. Fair d. Poor

21. Type of abutment (Circle one):

    a. Simple abutment b. End-dam c. U-shaped abutment

    d. Box shaped abutment e. Winged abutment.

22. Overhead clearance (feet): ______________

23. Height above water (estimate): ___________

24. Width of stream: ________________________

25. Depth of water (estimate): ______________

26. Direction of water moving: ______________

27. Type of banks:

    a. Height: _________________

    b. Slope: __________________

    c. Material: ______________

28. Fordable by tracked vechicles (Circle one): a. yes b. no

29. Fordable by wheeled vechicles (Circle one): a. yes b. no

30. Bypass information (possible bypass): ____________________________

31. Sketch or photos (include approaches): ___________________________

32. Remarks: ____

10.2.2.4 Urban Area Reconnaissance Report

1. Requesting unit: ______________________
2. DTG of Mission: ______________________
3. Map: Name: __________ Scale: __________ Sheet no.: __________
4. Grid squares covered: ______________________
5. Approx. pop. of city ______________
6. Main industry: ______________________
7. Secondary industries ______________________
8. No. of city blocks reconnoitered: ______________________
9. Approx. square miles of city: ______________________
10. Avenues of approach: ______________________
11. Power stations (coord): ______________________
12. Bridges: ______________________
13. Fuel pumps (coord): ______________________
14. Radio stations (coord): ______________________
15. Crops: ______________________

    Types: ______________________

    Storage at: ______________________
16. Engineering material at: ______________________
17. Piers (coord): ______________________
18. Hospital (coord): ______________________
19. Factories (coord): ______________________
20. Airports: no. of runways: ______________________

    Length of runways: ______________ Dir.: ______________
21. Schools (coord): ______________________
22. Water supply (coord): ______________________
23. Photographs taken:

    Camera types: ______________________

Film types:____________________

Number:____________________

Type:____________________

24. Railroads: From: __________ To:__________

    Sidings at: __________ Junction:__________

25. Dump sites/warehouse at (specify): __________

26. Obstacles:

    Natural: From: __________ To: __________

27. CP locations at:__________

28. OP locations at:__________

29. Enemy strongpoints at: __________

30. Bivouac/billeting areas at: __________

31. Landing strips at:__________

32. Helicopter landing sites at:__________

33. Traffic control points at:__________

34. Wheeled/tracked vehicles park:__________

    At: __________ Type: __________

35. Arty parks:

    At: __________ Type: __________

36. AAA Positions:

    At: __________ TYPE: __________

37. Remarks:__________

10.2.2.5 Rural Reconnaissance Report

1. Local name and military designation: ______________________

2. Type (homestead, village, or settlement): ______________________

3. Location (map sheet): ______________________

4. Nearest prominent feature

   Name: ______________ Type: ______________

   Location: ______________ Distance: ______________

5. Importance: ______________________

6. Cover and concealment: ______________________

7. Cross country movement: ______________________

8. Adjacent terrain: ______________________

9. Water supply:

   Type: ______________ Location: ______________

10. Area occupied/unoccupied-est. population: ______________________

11. Utilities:

    Type: ______________ Location: ______________

12. Street roads:

    Type: ______________ Const.: ______________

13. Buildings:

    Type: ______________ Const.: ______________

14. Building or areas whose destruction may cause adverse affects against friendly forces:

    ____

15. Features (fences-canals-ditches):

    Type: ______________

    Locations: ______________

    Const.: ______________

16. Avenues of approach: ______________________

17. Enemy activity: ______________________

10.2.2.6 Beach Reconnaissance Report

Observers:________________________ Date: ____________________

Map sheet name and number: ____

1. Coordinates: Left flank________________ Right flank____________________

2. Direction of current:

3. Type of coastline (convex, concave, straight):

*4. Offshore obstacle to landing:

Location Description

5 Beach description

a. Width:

b. Vegetation:

*c. Obstacles:

Location Description

*6. Beach exits:

Location Description

7. HInterland

   a. Vegetation

   b. Trafficability

*8. <u>Enemy sightings:</u>

<u>Location</u>	<u>Description</u>

9. <u>Remarks:</u>

*** Requires pictures**

10.2.2.7 Airfield/STOL Reconnaissance Report

1. Local and military designation: ______________________________

2. Map ref. - series: ______________ Sheets no.: ______________

   Scale: ______________ Coordinates: ______________

3. Runway(s) number: ______________ Length: ______________

   Width: ______________ Orientation: ______________

4. Surface type: ______________________________

5. Taxiways and parking areas: Number ______________ Size ______________

   Surface ______________ Revetted/unrevetted ______________

6. POL Location ______________ Size ______________ Surface ______________

7. Storage: Location ______________ Type ______________

8. Hangers: Location ______________ Size ______________

   Const. ______________________________

9. Enemy activity: Salute report

10. Transportation access: ______________________________

10.2.2.8 River Reconnaissance Report

Observer: ______________________ Date: ______________________

Map sheet and no.: ______________________

____

1. Coordinates: From: ______________________ To: ______________________

2. Average width: ______________________

*3. Obstacles to navigation (sand bar, rapids, falls, locks, dams, mines, etc.)

Location Description

*4. Possible fording points:

Location Description

*5. Possible ambush sites:

Location Description

*6. Piers/docking sites:

Location Description

*7. Craft/vessels sighted:

No.	Location	Description

*8. Enemy sightings:

Locations	Description

9. Remarks:

* Require pictures

10.2.2.9 Helicopter Landing Area (HLA) Reconnaissance Report

Requesting unit ____________________ Date ____________________

a. DTG of message ______________

b. Sketch, photo, or overlay or area enclosed:

Yes __________ No __________

c. Map: ____

d. Center coordinates: ________________________

e. Helicopter landing area: Zone ______ Site ______ Point ______

f. Classification of area: Excellent Good Fair Reject

g. Dimensions of area: Length ________________ Width ________________

h. Concealment (available to enemy and/or friendly): ____________________

____

i. Avenues of approach (evaluation/coordinates):

1. Resupply: ____________________________________

2. Linkup: ____________________________________

3. Barriers: ____________________________________

j. Distance to primary objective: ________________

k. Soil condition: ____________________________________

l. Ground obstacles: ____________________________________

m. Approach and departure obstacles: ____________________________

n. Water: ____________________________________

o. Slope: ____________________________________

p. Navigation aids:

1. ____________________________ 2. ____________________________

q. Wind encountered: ____________________________________

r. Evasion and pickup points: ____________________________

s. Routes to friendly area: ____________________________

Air observer: ____

10.2.2.10 Report of Surface Sighting

Name: ______________________ Roll number: ______________________

Date: ______________________ No. of last frame taken: ______________

1. Ship type: Circle type and subtype

   a. Fishing vessel:

      (1) Commercial (2) Sport fisher (3) Long liner

   b. Motor vessel:

      (1) Coastal freighter (2) Container ship (3) Tanker

      (4) Tug & Tow (5) Tug

   c. Sailing vessel:

      (1) One mast (2) Two mast (3) Three mast

   d. Other:

2. Length ft: 3. Name: 4. Homeport:

5. Hull color: 6. Trim color:

7. Superstructure color: 8. Waterline color :

9. Booms: (A mast with usually two arms extending with the ability to support or guide cargo)

   Forward: 1 2 3 4 5 Mid: 1 2 3 4 5 Aft: 1 2 3 4 5

10. Stack:

    1 2 3 Forward / mid / aft

11. Antenna:

    a. Radar 1 2 3 4 5 6 7 b. HF long wird: 1 2 3

    c. DF loop: 1 2 3 4 5 6 d. whip: 1 2 3 4 5 6

12. CTC DTC: 13. Position:

14. Course/speed:

15. Suspicious? Yes / no

    a. No fishing gear b. Too many people on board

    c. Oil drums d. Low in the water

10.2.3 General. The aerial observer must be prepared to submit overlays and sketches to amplify information and situations encountered during assigned missions.

10.2.3.1 Correct Overlays Should Contain The Following:

1. Tick marks lower left and upper right corners.

2. Should be complete but not cluttered. Two or more overlays may be made of the same area if required.

3. Overlays show only additions on the ground or deletions from the map of topographic and/or cultural features that no longer exist.

4. Required items:

   (a) Titile of overlay

   (b) Date/time group

   (c) Map sheet, name, and number

   (d) Map scale

   (e) Legend of non-standard symbols

   (f) Mission request reference number

   (g) Printed name, rank, and unit

   (h) Signature

10.2.3.2 Correct Sketches Should Contain The Following:

1. Should not be to scale but should be proportional.

2. Required items:

   (a) Title of sketch

   (b) Date/time group

   (c) Map sheet, name, and number

   (d) North arrow

   (e) Legend of non-standard symbols

   (f) Mission request reference number

   (g) Printed name, rank, and unit

   (h) Signature

   (i) Coordinates to center of sketch

3. General considerations

   (a) Neatness

   (b) Accuracy

   (c) Grid your area

   (d) Color whenever possible

10.3 AERIAL PHOTOGRAPHY/IMAGERY

For the purposes of OV-10 tactical employment, aerial photography is divided into hand-held and vertical strip methods of photography as explained in paragraph 10.18. The following information on aerial photography is not intended to be either a basic summary or an in-depth coverage of the subject. The material relates to tactical use of normal OV-10 photographic equipment only, and supplemental data for preflight planning reference is included. A basic knowledge of photography is not necessary for the pilot, but is essential to the aerial observer. This knowledge is acquired through the Aerial Observer School as a prerequisite to being designated an aerial observer. Military manuals on photography, and aerial photography in particular, are available if an individual desires to pursue the subject further.

10.3.1 Hand-Held Photography. Hand-held photography has the advantage of using relatively simple cameras of various designs to obtain oblique photographs which are composed in the camera viewfinder by the aerial observer. The aircraft altitude, airspeed, and position are adjusted by the pilot, based on directions given by the aerial observer to suit the particular mission requirements. This demands a substantial amount of aircrew coordination and proper preflight planning.

A disadvantage of hand-held photography is the difficulty in obtaining true vertical photographs, in spite of the OV-10 panoramic cockpit canopy. The necessity for the observer/ photographer to take his position in the rear cockpit limits his field of vision, because of the masking effect of the OV-10 structural design (front ejection seat structure, engine nacelles, propeller dome spinners, high wing, and cockpit obstructions). This, coupled with the aerodynamic difficulty in maintaining altitude while at approximately 90° of bank directly over the geographic point of interest, presents a challenge to both the pilot and aerial observer

To obtain sharp, clear, hand-held aerial photographs, both the pilot and the aerial observer have certain responsibilities. The pilot must reduce airframe vibration to a minimum by synchronizing the engines and propellers. This is best accomplished with the engine condition levers in the normal flight position and matching the engine rpm with the throttles, then synchronizing to eliminate the audible beat of the engines. Also, reduced airspeed and power settings, as aircraft safety and tactical requirements permit, decrease the effect of airframe vibration. Pilot techniques vary with the individual and the situation, but the objective is always to provide a stable vibration-free platform for the photographer. Smooth piloting is essential and can become difficult in turbulent air. Excessive positive or negative acceleration of the aircraft will greatly decrease the efficiency of the photographer. The pilot should attempt to maintain positive 1g flight during the time the photographer is taking pictures.

The aerial observer/photographer can also improve the quality of the picture. Blurred photographs result from excessive camera motion, which has several causes. A smooth shutter release and a steady trigger-squeeze are fundamental requirements. The camera must be isolated from aircraft vibrations as much as possible. The camera and the photographer's hands and arms should not touch any portion of the airframe, canopy, or ejection seat. Meanwhile, the camera lens should be as close to the canopy surface as possible (without touching it) to reduce refraction distortion from the plexiglass and reflective glare from the cockpit interior (light reflected from the instrument panel, knee board, or maps). Care should be taken to keep the canopy door lock handle out of the camera field of view and to choose an unscratched portion of the canopy which is relatively flat to minimize astigmatic aberration.

Added camera stability can be obtained if the photographer keeps his elbows against his chest while leaning away from the ejection seat with the shoulder harness unlocked. The upper torso of the body should absorb most of the vibration. Shutter speed is an important consideration. When flying in extremely gusty turbulence, use the fastest shutter speed possible consistent with proper exposure. A shutter speed of less than 1/100 second is not recommended because of the inherent aircraft vibrations. Absolute minimum shutter speed is dependent upon object to camera angular relative motion. Figure 10-2 lists minimum recommended shutter speeds.

Note

Larger lenses produce less peripheral distortion when stopped down one or two *f* settings from their maximum openings. This in turn requires slightly longer exposure times.

ALTITUDE (FEET AGL)	GROUND SPEED (KNOTS)			
	100	150	200	250
500	1/400	1/400	1/500	1/500
1000	1/200	1/250	1/400	1/400
1500	1/100	1/150	1/200	1/250
2000	— —	1/100	1/150	1/200
2500	— —	1/100	1/150	1/200
3000	— —	— —	1/100	1/200
3500 & Above	— —	— —	— —	1/100

Figure 10-2. Minimum Recommended Camera Shutter Speeds

Proper planning will ensure that the photography is not only clear but covers the target area in the desired scale. Use the data in Figure 10-3 to determine negative scale and area covered for vertical photographs using the 35-mm camera with a 100-mm lens. For obliques, consider the altitude figure as slant range; negative scale will be accurate only at the center of the picture. Horizontal ground covered (length) remains the same, but vertical ground covered (width) is not used. Use Figure 10-3 to compute slant range for various oblique angles.

10.3.2 Photograph Categories. Hand-held aerial photography consists of several categories. Those considered practical in the OV-10 are as follows.

10.3.2.1 Verticals. Verticals are aerial photographs which are exposed from directly overhead to the area of interest (perpendicular to the Earth's surface). This requires the pilot to momentarily stand the OV-10 on a wing tip while overflying the objective area to obtain a true vertical photograph. A true vertical aerial photograph becomes an up-to-date photo map when it is properly annotated with a north direction arrow, distance scale in meters, and one or more established reference grid coordinates. The main disadvantage is that details of terrain contour and object height are not readily apparent except where revealed by shadows.

ALTITUDE (FT AGL)	NEGATIVE	GROUND COVERED WIDTH/ LENGTH
100	1:305	7/10
200	1:611	14/21
300	1:917	22/33
400	1:1223	29/44
500	1:1529	36/55
600	1:1834	44/66
700	1:2140	51/77
800	1:2446	58/88
900	1:2752	66/99
1000	1:3058	73/110
1500	1:4587	110/165
2000	1:6116	146/220
2500	1:7645	183/275
3000	1:9174	220/330
3500	1:10703	256/385
4000	1:12232	293/440
4500	1:13761	330/495
5000	1:15290	366/550
6000	1:18348	440/660
6500	1:19877	476/715
7000	1:21406	513/770
8000	1:24464	586/880
9000	1:27522	660/990
10,000	1:30581	733/1100
11,000	1:33639	807/1210
12,000	1:36697	880/1320
13,000	1:39755	953/1430
14,000	1:42813	1027/1540
15,000	1:45817	1100/1648

Figure 10-3. Data for 35-mm Cameras With 100-mm Lens

10.3.2.2 Obliques. Aerial photographs that are not taken from the vertical are generally defined as obliques. Obliques are further subdivided into high and low categories. Although terrain contour and object heights are more easily discerned than they are from a vertical photograph, angular scale distortion precludes the use of an oblique photograph as a photo-map. Also, concealed enemy positions that are camouflaged from overhead detection may be revealed by oblique photography.

10.3.2.2.1 High Obliques. High obliques are aerial photographs that are exposed with a depression angle of less than 30° below the horizon (Figure 10-4). High obliques are usually shot at depression angles of 15° to 25° with the horizon included in the photograph for reference (approximately the upper quarter of the camera viewfinder).

10.3.2.2.2 Low Obliques. Low obliques are aerial photographs taken at a depression angle of 30° or greater below the horizon, but less than a vertical. For differentiation, low obliques are usually shot at 30° or 45° depression angle. They do not include the horizon in the photograph (Figure 10-4).

10.3.2.3 Pinpoints. Single photographs specifically aimed at a central object or area (buildings, airfields, cities, road/railroad intersections, and bridges).

10.3.2.4 Strips. Strips are a series of overlapping photographs aimed at long narrow areas (roads, railroads, rivers, canals, shorelines, and trails). It is important for the pilot to maintain a straight flightpath parallel to the desired strip and the photographer to obtain the necessary coverage between the start and stop points. A straight road, railroad, or trail should appear straight on the final composite photograph.

10.3.2.5 Orientation Shots. These views are used for orienting other photographs of the same target area and to encompass a larger area than pinpoints or strips so that prominent, easily identifiable map reference points can be annotated.

When considering views for orientation shots, aircraft position and altitude are important factors. The aircraft should be banked toward the area to be pho-

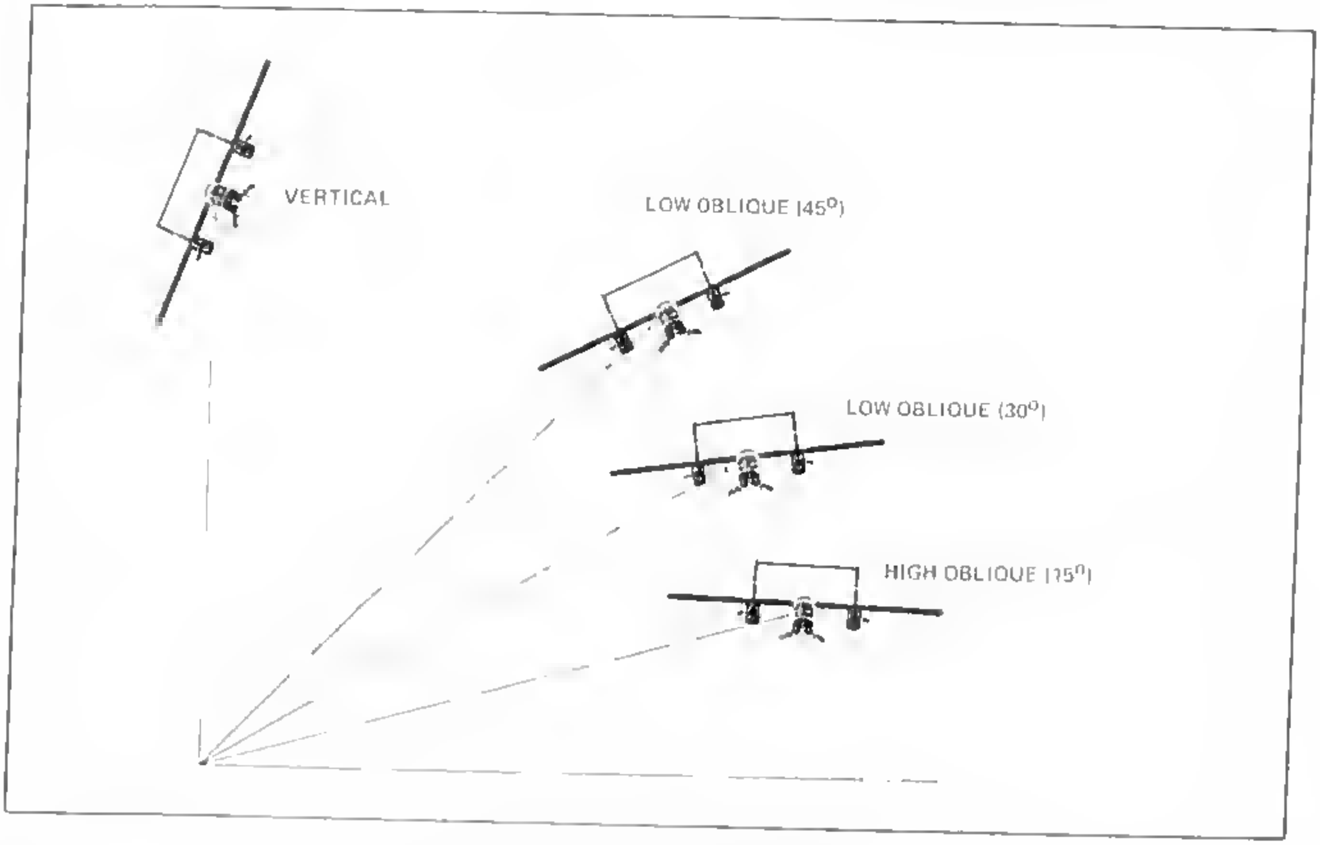


Figure 10-4. Hand-Held Aerial Photography

tographed except in the case of a strip photograph where the flightpath should be a straight line parallel to the desired area. Care should be exercised by the pilot to keep the propeller dome spinner from interfering with the photographer's field of view. The aircraft may be banked slightly away from the desired area during high oblique photography to improve the photographer's view.

Note

> Because of the relatively poor optical quality of the aircraft canopy side windows, the best photographic results are obtained by placing the camera lens surface parallel to the window surface. Astigmatic aberration may cause some blurring of the photo-image if the axis of the camera lens is oblique to the window surface.

The most desirable lighting conditions result when clear-to-scattered cloud conditions exist during mid-day (high noon, plus or minus 2 hours). Avoid taking pictures toward the sun. It is best to shoot with the sun behind the camera to reduce the veiling effect caused by atmospheric haze. The haze problem becomes more serious as the distance between the camera and scene increases (increased altitude or horizontal distance).

Haze filters (yellow) should be employed in aerial photography to absorb the scattered ultraviolet and blue light rays that are always present in varying degrees. The appropriate type of haze filters will depend on the type of film (black and white, color, infrared, or camouflage detection), the ASA speed of the film, the existing lighting conditions, the amount of haze, and the minimum acceptable shutter speed. Consult the appropriate camera and filter manuals and film brochures for recommendations.

10.3.2.6 Photo Log. It will be necessary for the aerial photographer to keep an accurate record of the photographs taken to properly annotate them after the film is developed. Figure 10-5 shows an example of a photo log that may be reproduced locally in kneeboard card size and used for this purpose. An additional technique that may be utilized to help associate a particular roll of exposed film with the mission it applies to is to have the photographer write his name, the tactical JTARS request information, and the date on a chalkboard in the ready room, prior to launch. Then he can take a picture of it on the first frame of the first roll of film he intends to use.

PHOTO MSN:			CAMERA :		
REQUESTED BY:			FOCAL LENGTH:		
DTG:			TYPE FILM:		
OBSERVER:			ASA:		
PHOTO	TARGET	COORDINATES	HDG L/R	ALT	REMARKS
1					
2					
3					
4					
5					
6					
7					
8					

Figure 10-5. Photo Log

10.3.3 Camera Equipment Precautions. Care of camera equipment and film is equally important. The aerial observer should take precautions to assure that no equipment will interfere with the operation of the flight controls (the control stick and rudder pedals), throttles, condition levers, flap handle, or landing gear handle at any time. The AO should especially be vigilant to prevent improperly stowed equipment from falling or jamming controls during flight in turbulence and on the ground while decelerating using reverse thrust and brakes.

Film should be stored under cool and dry conditions and should be exposed and developed prior to its expiration date for optimum results. Store film on-end (resting on its edge, not on its side). Remove film from cold storage 24 hours before its intended use to avoid condensation of moisture on the film emulsion.

The following photography preflight checklist is required in preparing for a successful mission:

1. Film — LOADED.

2. Lens cover — REMOVED.

3. Filter — INSTALLED.

4. Shutter speed and lens f-stop — SET. Compute according to exposure index with filter factor.

5. Focus — SET ON INFINITY.

Note

To prevent accidentally moving the focus ring, it should be taped in the infinity position (except for infrared film) with a suitable tape which may be removed when desired. For infrared film, adjust the ring 1/8-inch short of infinity.

6. Equipment/materials — STOWED.

10.3.4 FLIR Video Recorder. A video recorder, carried in the cargo bay, gives an increased intelligence-gathering ability. All imagery observed on the FLIR scope can be recorded on a video tape and replayed by the using unit, giving absolute information with no chance for misinterpretation by aircrews. Using units see imagery as it appeared in the aircraft, and the lack of processing permits immediate use of the imagery obtained.

10.4 ARTILLERY SUPPORT

The OV-10 crew, within their mission capabilities, must also be as familiar with artillery control as they are with air strike control. The crew must be familiar with the capabilities and characteristics of artillery weapons and ammunition and the considerations for their employment. Throughout history, artillery has

provided the preponderance of fire support on the battlefield.

10.4.1 Capabilities and Limitations of Artillery. Artillery is capable of providing close and continuous fire support, and its fires can be massed rapidly on critical points. Artillery, through its organizational structure and unique capability to provide timely, close, accurate, and continuous fire support, is better suited to the particular requirements of the ground forces than other supporting arms. The capabilities of the field artillery system are as follows:

10.4.1.1 Capabilities.

1. Rapidity of action — artillery possesses rapidity of action through its capability to rapidly deliver conventional fires and nuclear fires on targets over a wide front without displacement.

2. Massing capability — artillery is capable of massing the fires of many weapons on one or a series of targets to support the operations of ground forces. Successive volleys from one battery give the enemy time to react and seek protection, but massing the fires of several artillery batteries simultaneously will provide devastating results before the enemy can effectively react.

3. Fire without exposure — artillery is capable of sustained action in combat, since it delivers fire under all conditions of visibility, weather, and terrain.

4. Continuous support — artillery can deliver continuous support to maneuver units provided that artillery units make judicious displacements. Artillery unit movements must be carefully coordinated with the ground scheme of maneuver.

5. Variable trajectory — artillery variable trajectories enable attacking targets in defilade or fire from positions in defilade.

6. Surprise and shock — artillery can deliver fires without adjustment in order to increase the effects of shock and surprise. When it comes to casualty producing effects, surprise fires are significantly more effective than adjusted fires.

7. Mobility — artillery possesses the ability to displace rapidly to new positions. The artillery must be as mobile as the force it supports.

8. Target acquisition — forward and aerial observers play an important role in the target acquisition mission of the field artillery. Artillery/mortar locating radars also play a key role in locating high priority targets.

10. Variety of ammunition — one of the greatest capabilities of field artillery is its flexibility in providing a large variety of conventional and nuclear munitions.

10.4.1.2 Limitations. Limitations of the field artillery system include the following:

1. Initial support — the principal limitation of field artillery with a landing force is the inability to support the initial phase of the amphibious assault.

2. Displacement — artillery units supporting operations ashore have reduced effectiveness during displacement and are particularly vulnerable to air attack.

3. Weight — the weight of artillery weapons and their ammunition limits employment in support of the helicopter operation. The surface mobility is sensitive to the characteristics of the area of operations resulting in reduced capability to support the operation.

4. Space requirement — the requirement for position areas ashore for artillery, and the vulnerability to direct fire weapons, restrict the time of landing and entry into combat in both the waterborne and helicopterborne assault.

5. Logistic support — the logistic support problem may be difficult in air movement, helicopterborne, and amphibious operations because of the weight and volume of artillery ammunition requirements.

6. Firing signature — because of its large firing signature, artillery is especially vulnerable to enemy target acquisition and counter battery fires. Artillery units, especially nuclear capable artillery units, are highly lucrative targets and receive high priority for attack.

7. Close combat — when required to defend themselves and their weapons against ground attack, an artillery unit may be required to engage an enemy in close combat. In such cases, artillery support is significantly reduced until the attack is repelled.

10.4.2 Standard Tactical Missions of Artillery. A tactical mission is a set of fire support responsibilities assigned to an artillery unit. These missions are normally assigned by the artillery regimental headquarters on order from the Marine division. Tactical missions are

not usually assigned to artillery units smaller than a battalion. Aircrew should be familiar with who controls the fires of artillery units, depending on their tactical mission.

10.4.2.1 Direct Support (DS) Artillery. An artillery battalion is normally tasked with direct support of an infantry regiment. The direct support battalion provides an observer to the supported unit companies and liaison officers to its battalions. When working in support of ground units, aircrew should have a working knowledge of procedures for contacting that unit's direct support artillery. The direct support battalion answers calls for fire in priority from the supported unit, its own observers, and higher artillery headquarters.

10.4.2.2 Reinforcing. An artillery unit, normally a battalion, can be tasked to reinforce another unit, usually a direct support battalion. A reinforcing unit answers calls for fire in priority from the reinforced unit, its own observers, and higher artillery headquarters.

10.4.2.3 General Support Artillery. An artillery unit, normally a battalion, can be tasked with general support of the force as a whole. Its fires are controlled by higher artillery headquarters. A general support unit is best employed in the engagement of planned targets. This mission is sometimes referred to as the commander's *hip pocket* artillery unit, because it is immediately responsive to the need of the force commander.

10.4.2.4 General Support — Reinforcing. This mission provides immediate responsive fires for the maneuver force as a whole, while at the same time augmenting the fires of another artillery unit when available.

10.4.2.5 Dedicated Battery. A dedicated battery is a field artillery cannon battery whose total firepower is immediately available to suppress enemy direct fire weapons that threaten a designated maneuver company/team. The dedicated battery has direct fire planning and communication channels with the company/team and uses preplanned firing data and abbreviated procedures to answer calls for suppressive fires in less than 45 seconds. The dedicated battery's mission is normally assigned during a movement to contact or combat outpost assigned to a maneuver element.

10.4.3 Artillery Characteristics. Artillery and mortar characteristics are depicted in Figure 10-6.

10.4.3.1 Artillery Weapons Characteristics

10.4.3.1.1 81-mm Mortar, M129. Although technically classified as a mortar, the 81-mm mortar has long been known to Marine infantrymen as the battalion commander's *personal artillery*. An 81-mm mortar platoon is located in the weapons company of each infantry battalion and is responsive to the battalion commander. This smooth bore, muzzle-loaded weapon weighs approximately 116 pounds complete and can fire a 9.5-pound projectile to a maximum range of 4,575 meters. In addition to the standard high explosive (HE) projectile, white phosphorous (WP) and illumination (ILLUM) projectiles are available.

10.4.3.1.2 107-mm Mortar. The 107-mm mortar is found in the Army's division artillery. It has the capability to respond rapidly to calls for fire and provide a high rate of fire. This mortar fires the best illumination and smoke currently found in today's mortars. The 107-mm mortar is a muzzle-loaded weapon that weighs approximately 700 pounds complete and can fire a 35-pound projectile to a maximum range of 5,650 meters. In addition to the standard high explosive (HE) projectile, white phosphorous (WP), illumination (ILLUM), smoke (HC), and chemical (CS only) projectiles are available.

10.4.3.1.3 105-mm Towed Howitzer M101A1. This 105-mm Howitzer has been the backbone of Marine artillery since WWII. It is lightweight (about 4,980 pounds), versatile, and reliable. The M101A1 fires a 33-pound projectile about 11,000 meters and has maximum rate of fire of ten rounds per minute. The 105-mm fires HE, WP, ILLUM, smoke, antipersonnel (beehive), improved conventional munitions (ICM), gas (chemical) projectiles, and rocket-assisted projectiles (RAP).

10.4.3.1.4 155-mm Towed Howitzer M114A2. The M114A2 has many of the same traits as the M101A1. It too is WWII vintage and has been in the Marine inventory for three decades. This 155-mm Howitzer weighs about 12,700 pounds and is towed by the M900 series 5-ton truck. Its arsenal of ammunition includes many of the same type of projectiles as the 105-mm Howitzer. The M114A2 can be air transported by a CH-53A/D.

10.4.3.1.5 155-mm Towed Howitzer M198. The M198 has supplemented the M101A1 throughout the Marine Corps. The weapon features improved reliability and maintainability over the standard towed Howitzers. In addition to being able to fire all 155-mm ammunition in present stockpiles, the M198 is specifically designed to be used with new projectiles and propelling charges currently under development. When firing the new family of ammunition, the M198 has a range of about 18,000 meters with the standard projectile and 30,000 with the rocket assisted projectile (RAP). The increase in range is not achieved without a compromise in size over previous Howitzer systems. The M198 is significantly

Weapons	Range (M) See Note 1.	Approximate Operating Weight (Lb)	Reasonable Emplacement Time (Min)	Rate of Fire Rds/Min		Prime Mover	Ammunition See Notes 2 & 3		Weight of Standard HE Projectile (Lbs)	Burst Area (M)
				First 3 Min	Sustained		Projectile	Fuze		
105mm Howitzer Towed M101A1	11,000 14,500 (RAP)	4,980	3	10	3	2½ T Trk HELO	HE HE RAP ICM HEAT-T HEP-T	PD D VT MT CP	33	TN1 20x30 COMP B 20x30 20x30
105mm Howitzer Towed M102	11,500 15,100 (RAP)	3,140	4	10	3 2 Rds/Min First 30 Min 1 Rds/Min Thereafter or	5/4 T Trk HELO	Smoke HC Smoke WP Illum APERS T Leaflet GB H Chemical-CS	PD MTSQ MAMT		
155mm Howitzer Towed M198	18,150 Chg 8 24,000 Chg 8S 30,000 (RAP) 17,700 CHG 7	15,200	5	4	As Indicated By Thermal Warning Device	5 T Trk HELO (CH 53 E Only)	HE HE RAP ICM CLEP Illum Atomic	PD D UT M1 CP CP	95	30x50
155mm Howitzer Towed M114A2	14,600 19,300 (RAP)	12,700	5	4	1	5 T TRK HELO (Ch 53)	DPICM Chemical RAAM GB ADAM UX Smoke HC	BD MTSQ		30x50
155mm Howitzer SP M109A1/A2/A3	14,600 Chg 7 18,100 Chg 8 23,500 (RAP)	53,040	1	4	1 (Chg 1 2) 1 Rds/Min For First 60 Min Then 1 Rd Per 3 Min	SP	Smoke WP			30x50
8 in Howitzer SP M110A1/A2	16,800 20,600 Chg 7 22,900 Chg 8	62,100	3	1.5	0.6	SP	HE HE Spotting Atomic HE RAP ICM GB Chemical-VX	PD D VT MT CP MTSQ	200	30x80
81mm Mortar M29	4,695	98	1	10		Man Pack	HE WP Illum	PD UT D TI	9	34x30
107mm Mortar M30	5,650	670	1			M113	HE Chem WP (CS) Illum	PD VT D TI	35	20x40

CALIBER	# OF WPS PER BTRY GS/DS	SHEAF WIDTH (METERS)	SHEAF FRONT (METERS)
105mm Howitzer	6/8	150	180
155mm Howitzer	6/8	250	300
8 in Howitzer	6	400	480

Notes:

1. Maximum ranges are for standard HE projectile only – other projectiles may vary.
2. All projectiles are not compatible with all models.
3. All fuzes are not compatible with all projectiles.

Figure 10-6. Artillery Weapon Characteristics (Sheet 1 of 2)

Abbreviations:

ADAM – Area Denial Artillery Munitions
APERS – T-Anti-Personnel-Tracer (FLECHETTE)
BD – Base Detonating
CLGP – Cannon Launched Guided Projectile (Copperhead)
CP – Concrete Piercing
CS – Riot Control Agent
D – Delay
DPICM – Dual Purpose Improved Conventional Munitions
GB – Non Persistent Toxic (Casualty) Nerve Gas
H – Mustard Gas
HC – Hexachloroethane (Smoke)
HD – Distilled Mustard Gas
HE – High Explosive
HEAT – High Explosive Anti-Tank w/Tracer
HEP-T – High Explosive Plastic w/Tracer
ICM – Improved Conventional Munitions
ILLUM – Illuminating
LBS – Pounds
M – Meters
MAMT – Muzzle Action Mechanical Time
MT – Mechanical Time
MTSQ – Mechanical Time Super Quick
RAP – Rocket Assisted Projectile
RAAMS – Remote Anti-Armor Mine System
RDS/MIN – Rounds Per Minute
PD – Point Detonating (Quick)
SP – Self Propelled
T – Ton or with Tracer
TRK – Truck
VT – Variable Time (Proximity)
VX – Persistent Toxic (Casualty) Nerve Gas
WP – White Phosphorus

Figure 10-6. Artillery Weapon Characteristics (Sheet 2 of 2)

larger (over 40 feet long in the towed position and weighs 15,600 pounds) and requires a different prime mover (M900-series truck or LVTP-7) than the M114A2. The M198 is transported by the CH-53E.

10.4.3.1.6 155-mm Self-Propelled (SP) Howitzer M109A1. The M109A1 (SP) Howitzer is a highly mobile and responsive artillery system. It is widely used throughout the army and foreign countries such as Israel as the standard 155-mm Howitzer system for the heavy division. It fires a wide variety of ammunition and has a range of 18,000 meters with the standard projectile and 23,500 meters with RAP. The SP Howitzer has an enclosed turret that offers some degree of protection for the crew and weighs over 53,000 pounds.

10.4.3.1.7 8-inch Self-Propelled (SP) Howitzer M110A1/A2. The 8-inch system has long been heralded as the most accurate artillery weapon in the world. With its 200-pound projectile and pinpoint accuracy, it can deliver a devastating blow to enemy positions well beyond the forward edge of the battle area (FEBA). Even though it weighs about 62,100 pounds, the 8-inch is highly mobile on its self-propelled chassis. There is a good variety of ammunition available for the 8-inch Howitzer including chemical and nuclear projectiles. The present model (M110A1) can fire to ranges of 20,500 meters. With the M110A2, the range is extended to 30,000 meters if a RAP is used.

10.4.3.2 Artillery Ammunition Characteristics. A complete round of artillery ammunition contains all of the components necessary to propel the projectile from the weapon and cause it to burst at the desired time and place. The components are the primer, propelling charge, projectile, and fuze. Since choice of the proper projectile and fuzing is essential to mission success, the TAC(A) and FAC(A) must be familiar with the following ammunition characteristics.

10.4.3.2.1 Shell HE, Fuze Quick. Fuze quick causes the projectile to burst on impact. Shell fragmentation is very effective against personnel standing or prone on open ground and against unarmored vehicles and light material. Terrain has little effect on the ability to obtain fuze quick bursts. It is also very effective in high-angle fire. With heavy artillery, fuze quick may be used in indirect fire for destruction of armored vehicles.

There is very little effect against personnel in deep foxholes or trenches. The effect is greatly reduced if the ground is uneven or if shallow trenches are available. Little damage is done to frame buildings or earthworks.

10.4.3.2.2 Shell HE, Fuze Delay. The standard fuze delay with a 0.05-second delay element is normally used for either ricochet fire or penetration. A mixture of quick and delay is most effective against light frame houses and unarmored material and in dense woods.

a. Ricochet Fire. Ricochet action depends on the angle of impact (small), the terminal velocity of the projectile, and the nature of soil (not too soft) at the point of impact. When used for ricochet fire, fuze delay has several peculiarities. The height of burst is somewhat less than airbursts obtained with fuze time or fuze variable time (VT); this greatly reduces the effect of the shell against deeply entrenched targets. However, for targets in shallow trenches, the effect is somewhat better than that obtained from time fuze airbursts; the height of burst is lower and the projectile is in a different (noseup) attitude. Fuze delay (ricochet) is more effective than fuze quick against personnel in shielded areas (shallow foxholes).

The unpredictability of fuze action restricts the use of ricochet fire for neutralization. The higher the charge, the smaller the angle of impact; the harder the ground at the point of impact, the better the chance of obtaining ricochets.

If the shell does not ricochet, mine action may result, making the round useless against most targets. Delay fuze of ricochet action should not be used against standing or prone troops in the open. Use fuze quick instead.

b. Penetration. Penetration with delay fuze is effective against light earthworks, unarmored vehicles, and with the larger calibers, against sturdy houses (such as brick and stone) and heavier earthworks.

Fuze delay is not effective against concrete or heavy masonary; the fuze is crushed before the delay element can function, resulting in a low order burst of little effect.

10.4.3.2.3 Shell HE, Fuze Mechanical Time Super Quick (MTSQ). MTSQ fuzes can be set to detonate the shell at a given time along its trajectory. Normally this type of fuze is used to obtain airbursts over personnel. The height of burst can be controlled to produce any desired mean height of burst. Though not as effective as quick or delay fuze action against unarmored vehicles or light material, time fire is more effective for killing the personnel in such vehicles or those riding on tanks. It is very effective against personnel in the open, in trenches, or in deep foxholes.

Fuze time is very ineffective in high-angle fire because of the large height-of-burst probable error involved in long time of flight. Also, the necessity for determining and setting the appropriate fuze setting

results in time fire being slower than other types of fire. MTSQ has a quick fuze back-up feature that causes the shell to detonate upon impact.

10.4.3.2.4 Shell HE, Fuze VT. The proximity (VT) fuze is a radio-activated fuze that functions at a predetermined distance from any object. Thus, height of burst is automatically controlled.

The fuze combines some of the advantages of both the quick and time fuzes. Since the adjustment is performed with fuze quick and the height of burst is automatic, the ease and rapidity of adjustment are the same as for fuze quick. The fragmentation is similar to that of fuze time and is especially effective against entrenched personnel. It is the only fuze that will give effective air-bursts with high-angle fire. In addition, the automatic height of burst permits effective surprise and unobserved fire.

Certain types of VT fuzes are not recommended when the trajectory passes through visible moisture or if the target is on water, snow, or ice. A good target description will enable the fire direction officer (FDO) in the fire direction center (FDC) to determine which VT fuze is most appropriate.

10.4.3.2.5 Shell HE, Fuze Concrete Piercing (CP). These fuzes are constructed especially for use against concrete targets. Since it has a greater resistance to shock than the delay fuze, fuze CP should be used against hard surfaces, especially with weapons that will produce a high terminal velocity. The fuze is not used for area, neutralization fire.

10.4.3.2.6 Shell ICM (Improved Conventional Munitions). The ICM round is an HE, base-ejection type of projectile that consists of a mechanical time fuze and a body assembly with small grenades. When the fuze functions, the grenades are ejected to the rear. Centrifugal force disperses the grenades radially from the projectile line of flight. There are two types of ICM projectiles. The antipersonnel round (APERS ICM) uses a grenade in the form of a steel ball filled with explosives. When the grenade strikes the ground, a small charge ejects the ball 5 to 6 feet into the air where it detonates and scatters fragments over the target area. The number of grenades in each round depends on the caliber of the projectile: the 105-mm projectile contains 18 grenades; the 155-mm projectile carries 60 grenades; and the 8-inch projectile contains 104 grenades.

The antipersonnel/antimaterial round (DPICM) employs a dual-purpose grenade. The grenade has a high-explosive shaped charge that is effective against both material and personnel. There are 88 shaped charge grenades in a 155-mm round and 195 grenades in the 8-inch DPICM round.

10.4.3.2.7 Shell White Phosphorous, Fuze Quick, MTSQ, VT, or Delay. Shell white phosphorous (WP) is used for incendiary, casualty-producing, marking, and screening purposes. In appearance, the burst of shell WP armed with fuze quick is characterized by a fountain of brilliant white smoke and burning phosphorous. Small particles of burning phosphorous spread upward and outward as a pillar of smoke forms and rises. In all four roles of the white phosphorous shell (i.e., incendiary, casualty producing, marking, and screening), fuze quick is usually preferable to fuze delay, time, or VT. However, when employed in the attack of a frame building, some projectiles should be armed with fuze delay so that they penetrate the walls and the roof before detonating.

10.4.3.2.8 Shell Smoke Base-Ejection. Shell smoke is a base-ejection (BE) type of projectile that is filled with canisters containing smoke. The shell is always fuzed with a time fuze. The canisters in the smoke shell are filled with either white (HC) or colored smoke. The white smoke is used for screening friendly movement and to obscure the enemy vision. The colored smoke is used primarily for purposes of identification (marking) but may also be used for screening. In appearance, the smoke shell is characterized by a small burst in the air, which forces the canisters of smoke out of the projectile through its base. The ignited smoke canisters hit the ground and emit streams of smoke. The base-ejection smoke shell with time fuze is more effective as a screening agent than the white phosphorous smoke shell because it has less tendency to pillar and the smoke screen lasts longer. It is important to obtain airbursts when the smoke shell is employed. If the fuze is allowed to function too low, the smoke-producing effect of the shell will be reduced considerably. If the shell impacts the ground prior to the discharge of the smoke, the round will fail to function due to the lack of super quick back-up with the fuze utilized in this projectile/fuze combination. The direction of the wind must be considered in the employment of the smoke shell.

10.4.3.2.9 Shell Illuminating. The illuminating shell is a base-ejection type of projectile containing a cylindrical flare attached to a parachute. It is armed with a time fuze and has an expelling charge that ignites the flare and ejects the flare and parachute from the base of the shell. The flare attains full illumination about 10 seconds after being ejected and burns for about 60 to 120 seconds. The ejection of the flare and parachute at a height of 600 to 750 meters produces optimum illumination of the target area. When illuminating enemy forces, exercise caution to ensure that friendly troops are not exposed to enemy observation. Refer to

Cannon	Projectile	Initial Height of Burst (Meters)	Distance Between Bursts (Spread) (Meters)	Burning Time (Seconds)	Rate of Continuous Illumination (Rounds Per Minute)	Rate of Fall (Meters Per Second)
105mm	M314A2	750	800	60	2	10
105mm	M314A3	750	800	70-75	2	10
155mm	M118	750	800	60	2	10
155mm	M485A2	600	1000	120	1	5

Figure 10-7. Employment Factors for Illuminating Shells

Figure 10-7 for the capabilities of various illumination rounds.

10.4.3.2.10 High Explosive (HE) Rocket Assisted Projectile (RAP). The HE shell has all the basic characteristics of the standard HE projectile but can be fired at greater ranges. A small rocket motor ignites along the trajectory giving the projectile the extended range.

10.4.3.2.11 Leaflet (Propaganda). A base-ejected shell can be filled with literature and used as propaganda-type projectile.

10.4.3.2.12 Cannon-Launched Guided Projectile (CLGP). The CLGP is an artillery projectile with terminal homing capability. It is used to destroy or neutralize hard point targets such as tanks or field fortifications. The targets must be designated/illuminated with a laser that will provide the reflected energy to allow the projectile to home in on the target.

10.4.3.2.13 Family of Scatterable Mines (FASCAM). Two artillery delivered mine systems are now available: the area denial antipersonnel mine (ADAM) and the remote antiarmor mine system (RAAMS). As their names imply, the ADAM is an antipersonnel mine designed to attack dismounted enemy forces, and the RAAMS is designed to deliver antitank/antivehicle mines against the enemy armored/mechanized threat. Both systems have self-destruct capability. Self-destruct time settings are less than or greater than 24-hour fuze settings. The specific times are classified. The ADAM mines arm within a few seconds of hitting the ground and, when disturbed, will eject into the air and explode. The RAAMS mine contains a magnetic influence fuze and is capable of killing a tank.

10.4.3.2.14 Antipersonnel (APERS Flechette). The APERS or beehive round is primarily intended for antipersonnel use. The projectile body is loaded with 8,000 steel flechettes (darts) that are especially effective against personnel in the open or in dense foliage. Although the weapon is primarily designed for position area defense and short ranges, the time fuze makes it effective at greater ranges also. The APERS is available in 105 mm *only*.

10.4.3.2.15 Chemical. Both toxic and nontoxic chemical munitions are available for the field artillery. Some of these chemical agents include riot control (CS), nerve gas, and mustard gas. A new binary chemical projectile will soon be available. It is designed so the chemicals are not mixed into a lethal dose until the round is prepared and fired to the target. The advantage of this type of round is its stability and the safety afforded friendly personnel during storage and handling.

10.4.3.2.16 High Explosive Antitank-Tracer (HEAT-T). The antitank round is only found in 105 mm. It is designed with a shaped charge and is specifically intended for use against tanks and other armored vehicles. It is used in the direct fire mode only.

10.4.3.2.17 Nuclear. Tactical nuclear projectiles are available for 155-mm and 8-inch artillery weapons. Before an artillery unit is certified capable of handling, transporting, and firing nuclear weapons, it must successfully complete an inspection which demonstrates its proficiency to perform the required functions. Throughout the nuclear program, strict safety regulations are followed to eliminate the accidental or unauthorized detonation of nuclear weapons.

10.4.4 Artillery Communications. The OV-10 aircrew usually conducts artillery missions over the airspot net. There may be occasions when the airspot net is unusable, or the traffic is inappropriate for the net. The OV-10 aircrew should therefore have a working knowledge of artillery communications to facilitate the use of alternate nets.

The artillery communications system is an integration of radio, wire, multichannel radio, and teletype subsystems.

At the artillery regimental level, internal communications are established and maintained on the following nets:

1. Command

2. Tactical

3. Fire direction

4. Artillery radar telling

5. Artillery airspot

6. Artillery survey

7. Artillery metro.

The requirements for communications external to the artillery regiment are outlined in FMFM 10-1, Communications.

The conduct of fire net is used by the forward observers to request and adjust artillery fires. The conduct of fire net will terminate in the battalion or battery fire direction center depending on the degree of centralized control.

The artillery airspot net provides a means for aerial observers to transmit target information to artillery units and to adjust fires. Multiple airspot nets are generally required.

10.4.5 Artillery Fire Planning and Request Channels

10.4.5.1 Fire Planning. During fire planning, the OV-10 aircrew in support of maneuver units will encounter targets of opportunity which will be engaged immediately. They will also acquire targets upon which fires will be planned for engagement at some time in the future. The OV-10 aircrew is thus actively involved in the fire planning process and should have a working knowledge of artillery fire planning channels. The following paragraphs assume that such an analysis and assignment has taken place, and outline the fire planning channels followed for targets assigned to artillery.

10.4.5.1.1 Rifle Company Level. The artillery forward observer (FO), along with his fire support personnel (81-mm mortar FO, naval gunfire (NGF) spotter, forward air controller (FAC)), is briefed by the company commander concerning the company's mission, scheme of maneuver, and concept of fire support. Using the information obtained at the briefing, the FO plans artillery fires. He takes into consideration the areas of target planning and the phases of fires discussed in previous paragraphs. These fires are planned without respect to unit boundaries. The FO prepares a list of targets, submits it to the company commander for approval, then forwards it to the artillery liaison officer at the infantry battalion fire support coordination center (FSCC). The list of targets may be a written list delivered by hand, it may be accompanied by an overlay, or it may be transmitted by radio or wire communications. Targets will be given ABCA numbers by the artillery liaison officer after he consolidates the lists of targets for all FOs with the battalion.

10.4.5.1.2 Infantry Battalion Level. The fire support coordinator (FSC), with the infantry battalion, supervises the preparation of a list of targets for the battalion. These targets are derived from input from the S-2, the scheme of maneuver developed by the S-3, the rifle companies, and the commander's guidance. Duplications are resolved, the list is consolidated, target numbers are assigned, and the various targets are assigned to supporting arms. Once the initial plan has the approval of the S-3 and/or the battalion commander, the artillery liaison officer forwards the artillery targets to the artillery battalion fire direction center (FDC) and regimental FSCC. His FOs are then informed of the final decision regarding their targets.

10.4.5.1.3 Infantry Regimental Level. A nearly identical process takes place at the FSCC of the infantry regiment. Targets received from the S-2, S-3, regimental commander, and the maneuver battalions are consolidated and forwarded to the appropriate agencies to include the division FSCC. The artillery liaison officer sends the entire list of artillery targets to his battalion FDC, where personnel have already begun planning in response to the early input from the battalions.

10.4.5.1.4 Artillery Battalion FDC. The indirect support of the FDC artillery battalion is the focal point for artillery fire planning for the infantry regiment. The artillery battalion S-3 consolidates the target requests received from the regimental FSCC, combines them with input from his S-2 and from higher headquarters, and prepares the artillery fire plan for the infantry regiment. His fire plan is returned to the regimental FSCC for approval, and an additional copy is forwarded to the artillery regimental FDC for information requesting additional artillery support and ultimate consolidation at the division FSCC.

10.4.5.1.5 Artillery Regiment FDC. Fire planning at this level involves mainly the use of artillery units assigned a tactical mission of general support to the division. The artillery regimental S-3 prepares the artillery fire plan for the division. This plan includes the additional requirements initiated by the artillery battalion's request for long-range and reinforcing fires, the desires of the division commander, and the resolution of duplications arising from the total fire planning effort of the division. The division plan neither includes nor repeats the fire plans of the infantry regiments. Request for general support or general support reinforcing are forwarded to the general support battalion of the

artillery regiment. Requests for reinforcing fires are submitted to the reinforcing artillery battalion FDC. The regimental FDC will plan the fires of the general support and reinforcing artillery. All fires planned at the regimental FDC which fall within the zone of a lower echelon and the targets included on the target list are incorporated into an artillery fire plan. The completed fire plan is sent to division FSCC for approval by the division commander. The approved plan is then shotgunned to direct support, general support, general support/reinforcing, and reinforcing artillery units.

10.4.5.1.6 Final Target Analysis. A final note of importance in regard to artillery fire planning is required. Although targets generated and/or analyzed in the FSCC may be assigned to the artillery, it is in the artillery FDC that final target analysis takes place. The artillery battalion S-3 (fire direction officer) assigns the unit to fire on the target and determines the best ammunition and method of fire to achieve the desired effect on the target.

10.4.5.1.7 Artillery Support Request. As with all supporting arms, a request for artillery support will be approved most rapidly when it is submitted to the proper agencies. Figure 10-8 depicts the normal sequence of an artillery mission with aerial observer support requested by a company commander taking part in a division-sized operation. Whether in direct or general support, the firing battery obtains the required clearance to fire. Contact with the supported unit during the fire mission is desirable to provide on-going assessment of the mission's effectiveness. The artillery airspot net is the primary channel for operational control of aerial observers. It is normally located in the FDC of the senior artillery headquarters, but can also be found in the division headquarters and artillery battalions and batteries as required. The aerial observer will contact the FDC for instructions and mission approval. Once the mission is approved by the FDC, the mission is conducted in a manner similar to that of a ground observer.

10.4.6 Artillery Call for Fire. A call for fire is a concise message prepared by the observer containing all information needed by the FDC to determine the method with which to attack the target. The call for fire must be sent rapidly but with enough clarity that it can be understood, recorded, and read back without error by the FDC radio telephone operator (RTO). Information is sent as it is determined rather than waiting until a complete call for fire is prepared. After locating the target, the observer must send the location to the FDC. The FDC will convert the observer's target data into firing data for the guns. The observer's message is divided into six elements, some of which contain several supplements. Depending on the situation, some of these elements and supplements may be unnecessary and can be omitted. The complete message is called *call for fire*. It is important to include all the elements of the call for fire in the proper sequence. A normal call for fire contains six elements and is transmitted in a maximum of three parts with a break and readback after each part. A typical call for fire is shown in Figure 10-9, and an example airspot kneeboard card is found in Figure 10-10.

1. The first transmission announces the "OBSERVER IDENTIFICATION" and the "WARNING ORDER."

2. The "TARGET LOCATION" is identified in the second transmission.

3. The "TARGET DESCRIPTION, METHOD OF ENGAGEMENT" and "METHOD OF FIRE AND CONTROL" are included in the third transmission.

10.4.6.1 Identification of Observer. The observer identifies himself by his call sign.

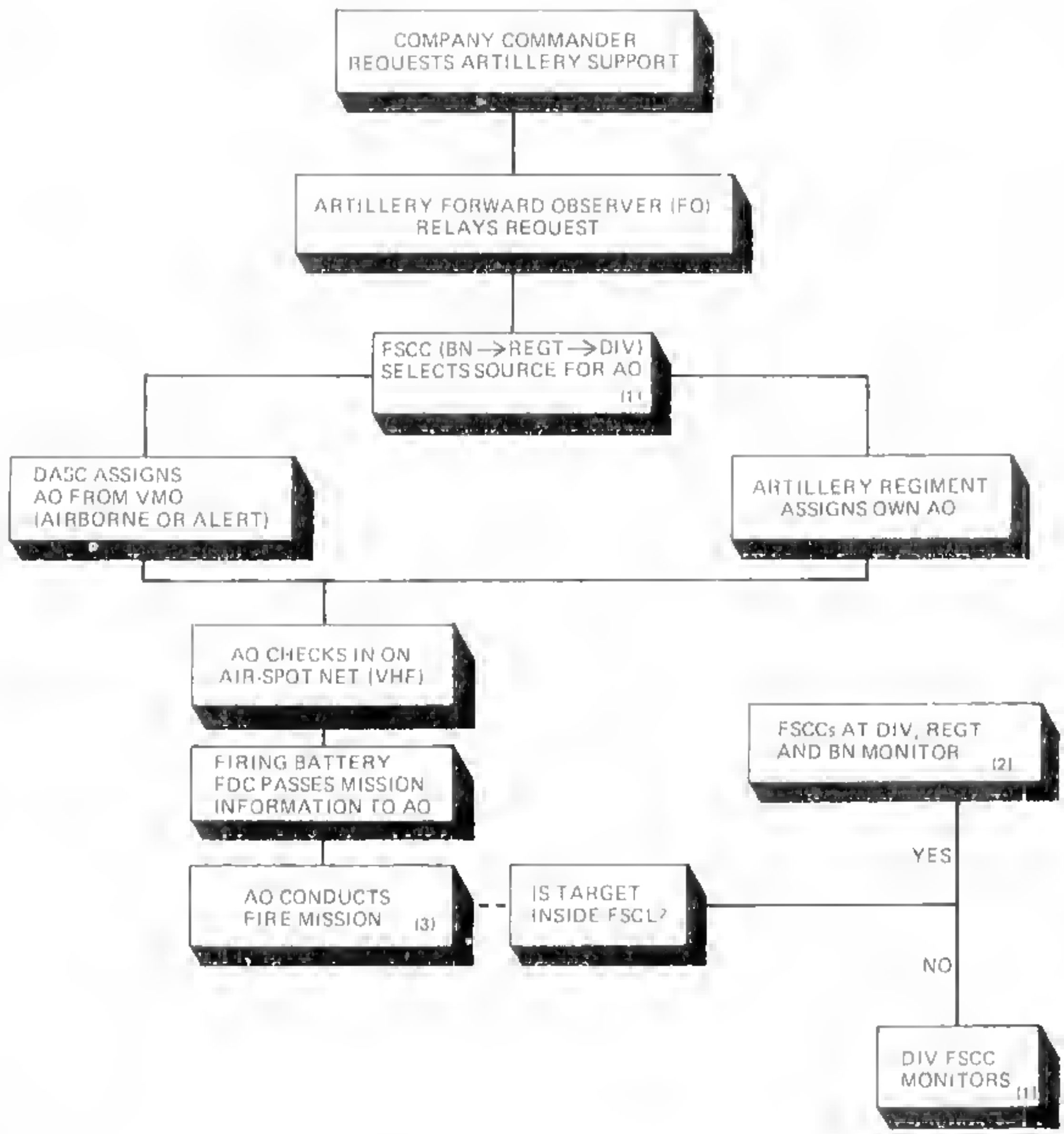
10.4.6.2 Warning Order. The warning order alerts the FDC that a fire mission is to follow. The mission will have priority on channels of communication. The three elements of the warning order alert the FDC to the relative urgency of the mission, whether massed fire is required, and the method the observer is going to use to locate the target. This warning order gives the fire direction officer (FDO) the necessary information he needs to assess priorities. It also assists the chart operators and computers to prepare to receive the next element in the call for fire, the target location.

10.4.6.2.1 Type of Mission. A fire mission may be one of four types.

1. Immediate suppression — the maneuver force is taking fire and urgently needs suppressive fire. In this case the observer will announce IMMEDIATE SUPPRESSION followed by the target number or location.

2. Suppression — fire is needed on a planned target or checkpoint, which, if occupied by the enemy, could jeopardize freedom of movement or accomplishment of the mission. A suppression mission is fired on a planned target that is not currently active.

3. Fire for effect — the observer is certain of the target location and does not desire to lose the element of surprise by unnecessary adjustments.



NOTES:

(1) Target cannot be observed by a ground observer.

(2) Silence indicates consent to fire the mission.

(3) To obtain target and friendly information during conduct of mission, the AO may contact the artillery FO on the conduct of fire net (FM). The firing battery also monitors this net.

Figure 10-8. Artillery Airspot Mission Flow Chart

ELEMENT	EXAMPLE
1 WARNING ORDER	"T1F THIS IS CZL ADJUST FIRE OVER"
READBACK	"CZL THIS IS T1F ADJUST FIRE OUT"
2 TARGET LOCATION	"GRID PG 934125 OVER"
READBACK	"GRID PG 934125 OUT"
3. TARGET DESIGNATION	"COMPANY"
4 METHOD OF ENGAGEMENT	"DANGER CLOSE SOUTH 500, HE, VT IN EFFECT OVER "
READBACK	"COMPANY - DANGER CLOSE SOUTH 500 HE, VT IN EFFECT OUT"
5. METHOD OF FIRE AND CONTROL	"AT MY COMMAND OVER"
READBACK	"AT YOUR COMMAND OUT"
MESSAGE TO OBSERVER	"FOX BATTERY - 4 ROUNDS TIME OF FLIGHT 24 (SEC), MAX ORD 850 (METERS) OVER"
OBSERVER READBACK	"FOX BATTERY - 4 ROUNDS TIME OF FLIGHT 14 MAX ORD 850 OUT"

Figure 10-9. Example Artillery Call for Fire

4. Adjust fire — if the observer is not confident of the location of the target, he warns the FDC by announcing that he plans to adjust onto the target.

10.4.6.2.2 Size of Element to Fire. If the observer intends to mass the fire of multiple units, he alerts the FDO to this fact in his warning order. In this case the observer will announce "BATTALION" or "ALL AVAILABLE" if he intends to fire for effect with more than a single battery.

10.4.6.2.3 Method of Target Location. If the observer has located the target by polar plot or shift from a known point, he alerts the chart operator in his warning order. The word "POLAR" is announced if the observer is using the polar plot method of target location. If the method of target location is shifted from a known point the observer announces "SHIFT" followed by the known point. Example: "S1J THIS IS B3H BN SHIFT AB2001 OVER." If neither shift nor polar are announced it is assumed that the grid method will be used.

10.4.6.3 Target Location. Target location may be reported in several ways, all of which must include a ground/map reference and the direction of the spotting line.

1. Grid coordinates — the target location is normally reported to the nearest 100 meters (six-place grid) when using grid coordinates. To indicate that coordinates are being used, the observer will announce "GRID" followed by the two-letter identifier and the six-place GRID. Example: "GRID PG 013718." The altitude of the target is not reported by the observer since it will be determined by the FDC. The observer-target (OT) direction need not be sent until the subsequent corrections are given.

2. Shift from a known point — if "SHIFT" is announced in the warning order, the spot from which the shift will be made is also announced as part of the warning order. For the target location the observer will send the OT direction. The OT direction should be expressed to the nearest 10 mils or 1°.

1 Observer Identification

________________ This is ____ ________

2 Warning Order

Adjust Fire

Fire for Effect

Suppress

Immediate Suppression

Size of Unit to Fire ________ ________

Method of Target Location Grid/Shift (Identify Known Point)

3. Target Location

Grid ________________

Shift OT Direction ____ Left/Right ____ Add/Drop ____ Up/Down ____

4. Target Description

5 Method of Engagement

Destruction

Area (Standard)

Danger Close (600M)

Trajectory High Angle/Low Angle (Standard)

Ammunition Projectile ________ Fuze ________ #RDS IN FFE ____

Distribution Ranging Rounds/Request Splash/Maximum Ordinate/Time of Flight

6. Method of Fire and Control

Method of Fire

Method of Control At My Command/Cannot Observe/Do Not Load/TOT

Message to Observer/Additional Information

1 Unit to Fire Unit in FFE ________ Adjusting Unit ________

2 Changes

3 Rounds in FFE ________

4 Time of Flight ________ 5 Maximum Ordinate ________

6 Probable Error ________ 7 Angle T ________

8 Target Number ________

OT DIRECTION

GTL/Cardinal Direction ________ /MILLS ________ /Degrees ____

Other ________________________

Figure 10-10. Example Airspot Kneeboard Card

Other methods of announcing OT direction such as cardinal direction or gun target line may also be used. In any case the observer must identify what he is using to measure the OT direction. Next, the lateral shift "LEFT" or "RIGHT" is announced. The lateral shift is expressed to the nearest 10 meters. The range shift, either "ADD" or "DROP," is then announced. Range shifts are expressed to the nearest 100 meters. If there is an obvious difference between the altitude of the target and that of the known point, a vertical shift is also announced by giving either an "UP" or "DOWN" correction. Vertical shifts are given to the nearest 5 meters. Unless there is an obvious difference, the vertical shift is ignored. As a rule of thumb, an altitude difference of less than two times the contour interval is ignored. Example: "DIRECTION 280°, LEFT 140, ADD 400, UP 35." When no maps are available and there has been no previous firing in an area, the observer may request "MARK CENTER OF SECTOR," and then shift from the marking rounds.

3. Target number — when the location of a target has been established by the FDC personnel and the observer prior to a flight, a target number may be given to it. In this case, the observer need only transmit the target number for his target location. Example: "TARGET AF2010." In this case, the artillery target list must be made available to the AO prior to launch.

4. The polar plot method is rarely used by the air observer, but it can be done by creating a false OP on the ground which is used to locate the target. The target will be located by announcing a direction to the nearest 10 mils, distance to the nearest 100 meters, and a vertical shift to the nearest 5 meters from the false OP. The FDC must know this location if polar is to be used. This technique may prove to be especially useful for the aerial observer, but make sure the FDC understands your transmission. This may require additional coordination and communication between the observer and the FDC since this technique is not routinely practiced. Example: "RIS THIS IS H3E ADJUST FIRE POLAR OVER." "FROM TARGET AB2411 DIRECTION 320°, DISTANCE 1,200 METERS OVER." "TANKS AND APC WITH TROOPS, DPICM IN EFFECT OVER."

5. Direction — the aerial observer makes spotting and corrections with respect to a spotting line. The fire direction center must know the direction of the spotting line in order to orient the target grid on the firing chart. Since the observer is moving continuously, his spotting line on the ground must be easily identified and distinctly visible. The observer should select a prominent cultural or terrain feature near the target to facilitate the target and spotting line identification. There are several spotting lines which the observer may select for use in making his adjustments: the gun target line (GTLN), identifiable terrain feature, cardinal direction, grid or magnetic azimuth. The OT direction can be announced in mils (to the nearest 10 mils) or degrees (to the nearest 1°). Magnetic azimuth is standard and need not be given in the call for fire, however, if a grid azimuth is given then that must be identified in giving the GTLN.

(a) Gun target line — this is an imaginary line from the firing unit to the target. If the observer knows the location of the weapons, visualization of the GTLN is facilitated. If he does not know the location of the weapons, the observer requests, "RANGING ROUNDS" in the distribution of fire. These two rounds fired at the same deflection, but 400 meters apart in range, will enable the observer to visualize the GTLN. The rounds are fired at a 5-second interval with the initial round being fired at the reported location. This round will be known as the *near round*. The second round will be fired 400 meters beyond and is known as the *far round*. The two terms will be used in the adjustment range phase of the mission. These ranging rounds also serve as a *yardstick* for estimating subsequent range and deviation correction. Use of ranging rounds is normally undesirable since it may facilitate the enemy's determination of the firing battery's position. Once the observer determines the direction of the GTLN, he should select terrain or cultural features such as a road, stream, or ridgeline which will assist him in remembering the direction. If no spotting line is stated by the observer, the GTLN will be used in the FDC as the spotting line.

(b) Reference line identifiable terrain — the observer may select a line formed by a road, railroad, canal, or any series of objects. To use this line, the observer must describe it in detail to the FDC so that its direction may be determined. Example: "DIRECTION HIGHWAY 1 FROM ONG BO BRIDGE TO KE HA BRIDGE."

(c) Cardinal direction — the cardinal points of a compass are sometimes used. If so, the cardinal direction should be converted to mils before announcing it to the FDC. Example: "SOUTH = 3,200 MILS."

(d) The aircraft heading indicator may provide accurate direction in some cases. If the aircraft

assumes a head-on posture, the reading on the heading indicator would indicate the observer-target OT line. The OT line is announced to the nearest 1° and is corrected if the OT direction changes by more than 10°. When making changes or subsequent corrections ensure the corrections are in relation to the new OT direction.

10.4.6.4 Description of Target. This element contains a brief but accurate description of the target to include degree of protection, number of personnel and equipment, size and shape, and the nature of the target activity that is observed. The description should be brief and concise but sufficiently informative to enable the fire direction officer to determine the relative importance of the target and best manner of attack. Example: "50 INFANTRY, 2 TANKS AND 1 TRUCK IN OPEN OR 2 MORTARS FIRING." It is not necessary to say "ENEMY SQUAD IN OPEN" for it is taken for granted that the observer is not shooting at his own friendly troops. If the target area is very large, the observer may include its size in meters and the altitude of the long axis to the nearest 50 mils, or 4°. Example: "400 X 200 ATTITUDE 290°." When the target area is circular the observer gives the radius. Linear targets may be described by two or more grids or by grid, length, and attitude.

10.4.6.5 Method of Engagement. This element is further broken down into five sub-elements which provide information regarding type of engagement, trajectory ammunition, and distribution of fire desired by the observer.

1. Type of engagement — two types of adjustment may be employed: area or precision. Unless precision fire is specified, area fire will be used.

(a) Area fire is used for attacking a dispersed target. Since many area targets are capable of movement, the adjustment should be as rapid as possible, consistent with accuracy to prevent the target from escaping. The observer must select a well-defined point at or near the center of the area to be attacked. This point is called adjusting point. Normally, adjustment on an area target is conducted with one adjusting gun. The observer need not request this type of fire. It can be omitted from his call for fire. To achieve surprise, fire may be adjusted on an auxiliary adjusting point and after adjustment is complete, shift to the actual target area.

(b) Precision fire is conducted with one piece on a point target. It is used to either destroy the target or obtain registration corrections for the battery. Registrations are initiated by a message to observer from the FDC. If the target is to be destroyed, the observer will announce "DESTRUCTION." This type of mission is very time consuming and normally will be assigned to a forward observer on the ground. For detailed instruction on precision registration/destruction procedures, refer to FM 6-30.

(c) The term *danger close* is included in the method of engagement if the target is within 600 meters of friendly troops for artillery and mortars. Along with the range element, the direction of the friendlies from the target should be given. In adjusting artillery during a *danger close mission*, the *creeping* method vice bracketing should be applied. This entails correction of no more than 100 meters as the rounds are moved toward the enemy position when they are within 600 meters of friendly positions. All weapons that will fire for effect will be used in adjustment.

(d) The term *mark* is used if the observer needs to orient himself in his zone of observation or to designate targets to ground troops, aircraft, or other fire support means. Example: "MARK TARGET #AB6001" or "MARK CENTER SECTOR." Generally, unit SOP calls for shell WP with fuze quick or time to be fired during these types of missions.

2. Type of trajectory — a choice of either low or high angle trajectories are normally available. When low-angle fire is desired, this supplement is omitted. If the observer desires high-angle fire, he must announce "HIGH ANGLE." When the observer omits a reference to trajectory, but computations in the FDC indicate high-angle fire to be necessary, the FDO will notify the observer that high-angle fire will be used.

3. Ammunition — this supplement permits the observer to request the type of projectile and fuze action desired. If this supplement is omitted, the observer will receive shell high explosive and fuze quick in adjustment and fire for effect. The observer must specify if he wants any shell fuze combination other than HE/Q. When the observer wants a combination of projectiles, and/or fuzes in effect, he must state in this supplement. Example: "HE AND WP IN EFFECT AND/OR VT." If the observer wants to adjust with one shell and fire for effect with another, he must so state. Example: "WP IN ADJUSTMENT, HE VT IN EFFECT." The observer may also indicate the volume of fire he considers necessary to accomplish the mission.

For example, if the observer has requested the battalion fire for effect and considers three rounds of shell HE and WP as the desired volume, he would announce "HE and WP, IN EFFECT, 3 ROUNDS."

4. Distribution of fire — this pertains to the *sheaf* in fire for effect. The term *sheaf* is used to denote the lateral distribution of the bursts of two or more pieces fired together. The width of the sheaf is the lateral distance (perpendicular to the direction of fire) between the center of the flank bursts. The front covered by any sheaf is the width of the sheaf plus the effective width of one burst. A parallel sheaf usually is fired on an area target in fire for effect and therefore need not be announced. When another type of sheaf is desired, the observer must so announce. Example: "CONVERGE OR OPEN SHEAF 100 METERS." If the observer desires to spread the fires of a battalion, he will request either "RANGE SPREAD OR LATERAL SPREAD.' The standard spread for a battalion is 1,000 meters between firing batteries.

10.4.6.6 Method of Fire and Control. This element indicates the manner in which the observer will attack the target, whether or not he desires to control the time of delivery, and whether or not he can observe the target.

1. Method of fire — in area fire, the adjustment normally is conducted with the one center piece of the adjusting battery. If for any reason the observer desires the weapons to fire from left to right, he must announce "PLATOON LEFT" or "PLATOON RIGHT." In a platoon right (left) the rounds are fired from the right (left) side toward the left (right) side. The normal interval of time between rounds fired by a platoon or battery right or left is 5 seconds. If the observer wants some other interval, he may so specify. Battery rights or lefts are very useful in checking a battery sheaf for weapons shooting unusually short or long.

2. Method of control — the control element indicates the control which the observer will exercise over the time of delivery of fire and whether an adjustment is to be made or fire is to be delivered without adjustment. Method of control is announced by the observer using one or more of the following terms.

(a) AT MY COMMAND (AMC) — this phrase indicates that the observer desires to control the time of delivery of fire. The observer announces "AT MY COMMAND." When the pieces are ready to fire, the FDC personnel announce *fire* when he is in position to observe the rounds impacting. AMC remains in effect until the observer announces "CANCEL AT MY COMMAND."

(b) CANNOT OBSERVE — this phrase indicates that the observer is unable to adjust fire; however, he has reason to believe that a target exists at the given location, and that it is of sufficient importance to justify firing on it without adjustment.

(c) TIME ON TARGET (TOT) — this phrase tells the FDC when the observer wants the rounds to impact around the target by requesting: "TIME ON TARGET 22 MINUTES FROM . . . NOW, OVER" or "TIME ON TARGET 0800 OVER." If the second technique is used remember to contact the FDC for a time check.

(d) TIME TO TARGET (TTT) — is used to request artillery in conjunction with a close air support strike (marking rounds or SEAD). In this case, the artillery mark will land in the area 20 to 30 seconds prior to the aircraft time to target. In this case, the TTT refers to the aircraft TTT and not an artillery TOT.

(e) FIRE WHEN READY — if nothing is specified regarding method of control, each section will fire when ready.

(f) CONTINUOUS ILLUMINATION — if no interval is given by the observer, the FDC will determine the interval by the turn time of the illumination round. If any other interval is required, it will be indicated in seconds.

(g) Coordinated illumination — the observer may order the interval between illuminating and HE shells in seconds to achieve a time of arrival of the HE coincident with optimum illumination, or he may use normal "AT MY COMMAND" procedures.

(h) Cease loading — the command "cease loading" is used during firing of two or more rounds to indicate the suspension of inserting rounds into the gun(s).

(i) CHECK FIRING — this command is used to cause a temporary halt in firing.

(j) CONTINUOUS FIRE — in field artillery and naval gunfire, this means loading and firing as rapidly as possible consistent with accuracy within the prescribed rate of fire for the

equipment. Firing will continue until temporarily suspended by the command "cease loading" or "check firing."

(k) FOLLOWED BY — this part of a term used to indicate a change in the rate of fire, in the type of ammunition, or in another order for fire for effect.

(l) REPEAT — during adjustment. Fire another round(s) at the last data, for any change in ammunition if necessary.

— During fire for effect. Fire the same number of rounds at the same method of fire for effect as last ordered. Alterations to the number of guns, the gun data, the interval, or the ammunition may be ordered.

10.4.6.7 Message to Observer (MTO). After the FDC has received the observer's call for fire, the fire direction officer will make a decision on how he wants to attack the target and the FDC personnel will begin to compute firing data for the guns. Shortly after a decision to fire the mission has been made, the FDC will furnish the observer with a "MESSAGE TO OBSERVER." The MTO consists of the following elements:

1. UNIT TO FIRE — this element consists of the battery or batteries to fire for effect.

2. ADJUSTING BATTERY — this element is included if more than one battery is firing for effect.

3. CHANGES — any changes or additions to the elements requested by the observer in the call for fire will be included in this element.

4. ROUNDS — this element contains the round per tube to be fired in fire for effect. If the observer receives 3 rounds in this element, he should observe 18 rounds impacting during fire for effect providing he is receiving a full six-gun battery.

10.4.6.8 Additional Information. It may also be necessary for the FDC to pass additional information regarding the mission to the observer. If required, the following information may be sent separately from the message to observer.

1. TIME OF FLIGHT — the time of flight is sent to the aerial observer to facilitate aircraft orientation. This indicates the time in seconds for a projectile being fired to its impact. If the time of flight changes more than 5 seconds from that originally announced, the new time of flight will be announced. Five seconds before the round impacts, FDC will announce "SPLASH" to the observer.

2. PROBABLE ERROR — if the probable error is greater than 38 meters, then the FDC will announce it in the message to observer. The observer should not attempt to split a 100-meter bracket in this case.

3. ANGLE "T" — if the observer is using a reference line other than the GTL for adjustments, the FDC will report the angle "T" if in excess of 500 mils, or when requested by the observer.

4. TARGET NUMBER — if a target has been recorded, the FDC will send the observer the replot grid as soon as available. Target numbers will not be assigned to targets of opportunity unless:

(a) The observer requests it (and the FDO agrees).

(b) The FDO (or FSCC) directs that it be recorded as a target.

(c) The target number will be sent at the completion of the mission.

10.4.7 Adjustment Techniques (Area Fire). During the conduct of area fire missions one of several adjustment techniques may be employed:

1. After the first definite range spotting the observer will send a correction to the FDC to establish a bracket around the adjusting point. If the successive bracketing technique is used, the observer will successfully split the bracket until the next correction will bring the rounds within 50 meters of the adjusting point at which point he will center fire for effect (FFE).

2. If the observer is more experienced or time is critical, the observer may use the *hasty bracketing* technique. After the initial range bracket is established, the observer will determine one subsequent correction and enter .

3. Auxiliary aiming point — to achieve maximum benefit from the element of surprise the observer may utilize an adjustment technique that incorporates an auxiliary aiming point or auxiliary adjusting point. What the observer does in this case is adjust onto a point near the target but far enough away so that the enemy does not realize what the actual target is. Once adjusted onto the auxiliary adjusting point, the observer makes one final bold shift and enters fire for effect. Caution must be taken to ensure that an accurate (preferably lateral)

shift can be made. A shift too large may cause inaccuracies that may result in little or no effect on the target.

4. Creeping fire — is used during danger close missions and involves use of small corrections that progressively creep toward the adjusting point. It is used when care must be taken to ensure safety for friendly troops.

10.4.8 Fire for Effect (FFE) (Figure 10-11). In area fire, FFE is started when a suitable adjustment has been obtained; that is, when deviation and range are correct or when splitting the range bracket will produce effective fire. With time fire, FFE is not started until a range bracket of 100 meters has been established with fuze quick and the height of burst is correct, or until the observer is certain that his next vertical correction will result in the correct height of burst. Fire for effect is not to be started if the last rounds observed were all graze bursts. If ricochet action was sought in the adjustment, the use of fuze delay is continued in fire for effect when at least 50 percent of the bursts that established the 100-meter bracket were ricochets (airbursts). If less than 50 percent of the bursts were ricochet, fuze VT or fuze quick is used in FFE.

If FFE is accurate but insufficient, the observer may announce *repeat*. If any element of the adjustment (deviation, range, or height of burst) is in error enough to partially nullify the effectiveness of the fire for effect, the observer should correct the element or elements in error and continue the fire for effect; for example, add 50, down 10, repeat. If ricochet fuze action was sought in fire for effect and less than 50 percent of the bursts were ricochet, the fuze is changed to fuze VT or fuze quick for subsequent fire for effect.

10.4.9 Sequence of Subsequent Corrections. After the initial bursts appear, the observer will transmit changes in the call for fire and corrections for deviation, range, and height of burst as appropriate. Here are the subsequent corrections that may be necessary and the sequence they are transmitted in.

1. Whenever the "OBSERVER TARGET DIRECTION" changes by more than 100 mils or 10° from that previously announced, the new OT direction must be announced.

2. If during the adjustments of artillery fires, correction is made that will cause the rounds to land within 600 meters of friendly troops, the observer would announce "DANGER CLOSE" as part of his subsequent corrections. If an adjustment moves the rounds more than 600 meters from friendlies, the observer would transmit "CANCEL DANGER CLOSE."

3. Whenever a change in trajectory is needed, the observer may change from low angle to high angle by announcing "HIGH ANGLE" or from high angle to low angle by transmitting "CANCEL HIGH ANGLE."

4. If the observer desires to change the "METHOD OF FIRE" he does so by simply transmitting the correction.

RESULTS OF FFE	FO'S ACTIONS
1. ACCURATE AND SUFFICIENT	EM, SURVEILLANCE, (END OF MISSION, RPG SILENCED)
2. ACCURATE, SUFFICIENT, TARGET REPLOT DESIRED	REQUEST REPLOT, EM, SURVEILLANCE (RECORD AS TARGET, END OF MISSION, BMP NEUTRALIZED)
3 INACCURATE AND SUFFICIENT	REFINEMENT, EM, SURVEILLANCE (RIGHT 20 ADD 20, END OF MISSION, RPG SILENCED)
4. INACCURATE, SUFFICIENT, TARGET REPLOT DESIRED	REFINEMENT, REQUEST REPLOT, EM, SURVEILLANCE (RIGHT 10 RECORD AS TARGET, END OF MISSION, BMP NEUTRAULIZED)
5. INACCURATE AND INSUFFICIENT	REFINEMENT, REPEAT OR REENTER ADJUST FIRE (RIGHT 10 ADD 30 REPEAT)
6 ACCURATE AND INSUFFICIENT	REPEAT (REPEAT)

Figure 10-11. Fire for Effect

5. Whenever a change in "DISTRIBUTION" is in order, the observer will transmit the desired sheaf. If he is changing from a special sheaf to a parallel sheaf, the correction is made by announcing "CANCEL" followed by the type of sheaf being used.

6. In order to change the type of "PROJECTILE" being fired, the observer will announce the desired change.

7. Likewise, if the observer wants to change the "FUZE" or "FUZE ACTION" he will announce the desired change.

8. To change the "VOLUME OF FIRE," the observer announces the change.

9. Corrections for deviation, range, and height of burst (HOB) are next in the sequence of subsequent corrections. If a correction for deviation is required to bring the bursts back to the observer target line, the observer will transmit "RIGHT/LEFT" followed by the deviation to the nearest 10 meters. If a correction for range is necessary, the observer will announce the correction as an "ADD" or "DROP" so much. A correction for HOB is expressed to the nearest 5 meters and announced as an "UP" or "DOWN" correction. The desired HOB is 20 meters. In an area mission, HOB corrections are made after the deviation and range are corrected to within 50 meters of the target using fuze quick in adjustment.

10. To change the method of control the observer will transmit the desired method of control. To change the method of control from "AT MY COMMAND" the observer would transmit "CANCEL AT MY COMMAND."

11. The observer may request "SPLASH" to help him identify the rounds being fired. The FDC will inform the observer that the rounds are about to impact by announcing "SPLASH" 5 seconds prior to impact.

12. "REPEAT" may be used during the adjustment phase of the fire for effect phase. If used during the adjustment, the firing unit will fire another round(s) at the last data fired. The observer may make adjustments in shell/fuze combination only. Example: "TIME REPEAT." If repeat is used, the firing unit will fire the same number of rounds at the same method of fire for effect as last ordered. Changes to number of guns, the gun data, the interval, or the ammunition may be made by the observer. Example: "LEFT 20, ADD 200, ICM REPEAT."

10.4.9.1 Corrections of Errors. Errors may be made by the observer transmitting erroneous data or by the FDC personnel transmitting an incorrect read-back. If an observer realizes that he has made an error in his transmission, he announces "CORRECTION" and transmits the corrected data. If the observer notes the FDC read-back is incorrect, he announces "CORRECTION" and transmits the correct data. When an observer sends erroneous data in subsequent corrections, which are related to target location, such as deviation, range, or height of burst, he corrects the errors by announcing "CORRECTION" followed by the entire correct target location. For example, if the observer has transmitted "LEFT 20, AND ADD 400, UP 40," and he desires to change add 400 to drop 400, he sends "CORRECTION, LEFT 200, DROP 400, UP 40." The word "CORRECTION" in this case cancels the entire previous target location. If anything unrelated to target location is omitted or transmitted in error, the observer announces "CORRECTION" and transmits the omitted element or retransmits correctly the element erroneously transmitted. For example, after the observer has transmitted "SMOKE, RIGHT 200, ADD 400, UP 20," he realizes he should have requested WP instead of shell smoke; therefore, he only announces "CORRECTION WP."

10.4.10 Surveillance and Refinement Data. On completion of fire for effect (if the target has been neutralized and the fire was effective and sufficient), the observer will announce "END OF MISSION" and report the effect observed; for example, infantry dispersed. If the observer desires to make a correction to improve the accuracy of the replot of the target but does not wish to fire again, he will announce the correction; for example: "LEFT 20," followed by the words "END OF MISSION" and the surveillance. There are, of course, several other combinations of surveillance and refinement possible. These combinations are shown in Figure 10-10.

10.4.11 Special Missions. The procedures previously discussed are common to all observed fire missions. Special consideration must be given to certain types of missions that employ ammunition other then HE. Some of the less frequently employed missions include the use of ICM, smoke, or illumination projectiles.

10.4.11.1 Improved Conventional Munitions. ICM is a base ejection projectile employing two different types; antipersonnel and dual purpose. Deviation shifts of less than 50 meters and range shifts of less than 100 meters should not be made. HOB corrections are made in increments of 50 meters and should be made only if more duds are observed, or the effects pattern is too small. If ICM is used in a situation that requires the use of *danger close*, the observer must start at least 600

meters from friendlies and adjust with the entire battery The adjustment should be made from the near edge of the effects pattern.

10.4.11.2 Family of Scatterable Mines (FASCAM). The observer techniques for FASCAM, ADAM, and RAAM are similar to the procedures used when adjusting ICM. If the mission requires observer adjustment, the round used in adjustment will be DPICM in the self-registration (SR) mode. The adjusting point or aim point is placed on the axis of advance at a distance of 1,000 meters in front of the enemy for every 10 km/hr or forward speed. If the target is stationary, the aim point is placed directly over the target center. The call for fire for FASCAM is similar to the call for fire for other projectiles with the following exceptions:

1. The warning order will include the type of projectile (ADAM, RAAM, or both).

2. If the target is located by grid coordinate at six place, grid is adequate.

3. Short self-destruct time is standard; if long self-destruct time is required, it must be requested (FFE, ADAM-6).

10.4.11.3 Illumination. Battlefield illumination has many uses in combat. It provides friendly forces with sufficient light to assist them in ground operations at night. When properly used, night illumination increases the morale of friendly forces, facilitates operations, and harasses and blinds the enemy.

The size of the area that can be effectively illuminated depends on the observer distance, conditions of visibility, and candlepower of the shell used. If the area to be illuminated is large or the observing conditions are poor, the firing of only one round of illuminating shell at a time may be inadequate. In order to provide various degrees of illumination, illumination missions may be fired with one gun, with two guns firing so that the rounds burst simultaneously at the same place, with two guns firing with a range or lateral spread between the bursts, or with four guns firing so that the bursts form a diamond pattern over the point of illumination. Two rounds bursting simultaneously at approximately the same place produce better lighting in an area than does one round. Two rounds may be used when observing conditions are poor because of haze, dust, or long observing ranges. The observer obtains this type of illumination by requesting "TWO GUNS" illumination in the call for fire.

For two rounds set to burst simultaneously in range along the gun target line, the observer requests "ILLUMINATION RANGE SPREAD." Two rounds fired at the same range with a lateral (deflection) spread will likewise give better illumination than one round and will reduce the shadows resulting from a single flare. When this type of illumination is desired, the observer includes in his call for fire "ILLUMINATION LATERAL SPREAD." In this case, illumination given as the type projectile and range/lateral spread is given as the distribution. The distance between bursts in both cases will be 800 meters for 105-mm and 1,000 meters for 155-mm projectiles. For searching an area, the bursts from four pieces are placed 800 to 1,000 meters in a diamond pattern around the target. Two pieces will fire a lateral spread at the range to the area, and two pieces will fire a range spread at the deflection to the center of the area. To achieve this pattern the observer requests "ILLUMINATION, RANGE AND LATERAL SPREAD."

When the observer calls for a range or lateral spread or a diamond pattern the FDC centers the pattern over the point indicated by the observer.

10.4.11.3.1 Subsequent Correction. The correct position of the flare to the adjusting point depends on the terrain and the wind. The point of burst should be such that the final travel of the flare is not between the observer and the adjusting point. In a strong wind, the observer should place the point of bursts some distance from the adjusting point so that the flare will drift to the desired location near the target. Generally, the position of the flare should be slightly to one flank of the adjusting point and at approximately the same range. If the target is on a forward slope, the flare should be on the flank and at a slightly shorter range. If the adjusting point is a very prominent target, better visibility may be obtained if the flare is placed beyond the target to silhouette it.

Range and direction are adjusted by use of standard observed fire procedures with the minimum correction being 200 meters.

The height of burst is correct when the flare stops burning just before it strikes the ground. Changes in height of burst are made in multiples of 50 meters; for example: "DOWN 100." "The slight variations in the times of burning of flares render useless any closer adjustment of the height of burst. When the point of burst is too high, the required change is estimated from the height of the flare when it burned out. When the point of burst is too low, the required change is estimated from the length of time (T) in seconds the flare burned on the ground. The approximate rate of descent is 10 meters per second for the M134 (105 mm) and 5 meters per second for the M485 (155 mm).

By multiplying "T" by 5 to 10, depending on the type of shell being fired, the observer can determine the approximate correction required for the height of burst.

10.4.11.3.2 Continuous Illumination. If the adjusting point is to be kept under illumination, the observer sends the request "CONTINUOUS ILLUMINATION." On receipt of this request, the FDC makes sure that a new shell bursts over the point indicated by the observer just before the burnout time of the old flare.

10.4.11.3.3 Coordinated Illumination. Coordinated illumination deals with the attack of targets with HE or other artillery ammunition during period of darkness. To properly identify targets, observe and adjust the fires. Coordinated illumination must be fired. For the most part, a coordinated illumination mission will start out as a basic adjust fire mission with shell "ILLUMINATION" given for the type of projectile to be fired. After the illumination is adjusted to the point where a target suitable for attack by HE or other projectiles can be observed, a coordinated illumination mission is initiated. These missions may be conducted in three different ways.

1. The FDC can control the firing of the HE so it arrives in the target area at the time of best visibility or maximum illumination. This is done by the observer announcing "COORDINATED ILLUMINATION" in his call for fire. When the illumination in the target area is at its maximum, the observer will announce "ILLUMINATION MARK" to the FDC. This will enable the FDC to compute the correct time to fire the HE rounds so they arrive at the target during the period of best light.

2. "COORDINATED ILLUMINATION" is also announced for an alternate method of coordinating HE and illumination missions. However, this time the observer announces "BY SHELL AT MY COMMAND" as the method of control. The primary difference between this procedure and the one previously discussed is that the FDC must inform the observer when both shell types are ready to fire. Then the observer will coordinate the fires by announcing "ILLUMINATION FIRE" and a few seconds later he will command "HE, FIRE" so that the HE will arrive during the period of maximum illumination of the target.

3. A third method of coordination between HE and ILLUM fires is requesting "CONTINUOUS ILLUMINATION." For this method, the FDC will compute the interval required to maintain the proper level of illumination over the target and the battery will fire continuously while the observer adjusts the HE. This is the least desirable method because of the large amount of ammunition expended.

10.4.11.4 Smoke. If properly used, smoke projectiles can significantly reduce the enemy's effectiveness. The two basic smoke projectiles are HC and WP. The two primary purposes of smoke are to obscure enemy vision or to screen maneuver elements. The observer must take several factors into consideration when using smoke.

1. Weather has a great influence on the effectiveness of smoke. Wind direction and speed, temperature, and humidity must all be considered.

2. The amount and type of ammunition available could have a significant impact on your ability to utilize smoke.

3. The terrain could influence the effectiveness of a smoke mission. Smoke seeks low spots, and canisters may roll downhill if fired into steep terrain. In addition, smoke should not be used on deep mud, water, or snow, as the canisters will not function properly.

4. A primary consideration for the observer is the commander's guidance. Remember that the commander must approve the employment of smoke. If improperly used, smoke could work to your disadvantage.

5. Enemy tactics, equipment, and capabilities must be considered. Smoke fired on enemy observation posts and flash ranging bases greatly reduces the effectiveness of their artillery. A combination of smoke and HE can be very useful in confusing the enemy, especially if he is changing tactical formations or transversing minefields.

Two basic adjustment techniques are used in the conduct of smoke missions.

1. An immediate mission is used to obscure the enemy's vision and is used primarily against small area or point targets. The conduct of smoke is similar to an immediate suppression mission and is largely based on local SOP. When adjusting immediate smoke, minimum correction for deviation is 50 meters and for range it is 100 meters. HOB corrections are made in increments of 50 meters. The following guidelines are suggested for HOB adjustments:

(a) Ground burst — up 100

(b) Canisters bouncing excessively — up 50

(c) Canisters to spread out — down 50.

2. Quick smoke is used to obscure enemy vision or screen maneuver elements. The mission is begun by adjusting with HE and then shifting to smoke. Quick smoke will obscure a larger area, normally up to 600 meters, for a longer time than an immediate smoke mission. Larger areas may be screened by using multiple aim point. Additional information that is necessary for the FDC to determine how many rounds are needed in effect, and the interval of the rounds, includes target length, wind direction, and length of time the smoke is desired. If multiple aim points are needed, the location of the second/subsequent aim point must be prefaced by announcing "SECOND AIM POINT" followed by aim point location and "REPEAT." "Example: "SECOND AIM POINT" DIRECTION 1,200 MILS, RIGHT 200, ADD 400, REPEAT." A combination of HC and WP is used in the FFE phase.

10.4.11.5 High-Angle Fires. There are several procedures unique to high-angle fires.

1. High-angle is fire delivered at elevations greater than the elevation for maximum range, to effect a mortar type trajectory. It is often required when the weapons are firing out of a deep defilade, from within cities, or over high terrain features near friendly troops; or when targets cannot be reached by a low-angle fire because they are located directly behind hill crests, in jungles, or in deep gullies or ravines.

2. When high-angle fire is desired, the observer includes high-angle fire as the type of adjustment in his call for fire, as the method of engagement.

3. The observer procedure for the adjustment of high-angle fire is the same as that for low-angle fire.

4. Ricochet fire is not possible because of the steep angle of fall. Excessive height-of-burst probable error in high-angle fire prohibits the use of time fuze. The steep angle of fall gives the maximum effectiveness in all directions of the spray of a quick fuze shell. This effect with variable time VT fuze is combined with a much lower height of burst than normally is obtained from VT fuze in low-angle fire. Either fuze quick or fuze VT may be used effectively.

5. The observer must realize that small corrections during adjustment may be unnecessary and time consuming because of the increased dispersion experienced during high-angle fire.

6. Because of the long time of flight, the FDC, in both the adjustment and fire for effect, announces "SHOT" when the round or rounds are fired and announces "SPLASH" 5 seconds before the burst or bursts occur. If the mission is observed by an air observer, the FDC announces "SHOT, TIME OF FLIGHT," and "SPLASH."

10.4.12 Special Techniques for the Air Observer. Adjustment of artillery fire by the aerial observer varies only slightly from the techniques used by the ground observer. The call for fire and subsequent corrections are the same for both aerial observers and ground observers.

10.4.12.1 Spotting Line. There are several spotting lines that the aerial observer could use.

1. A spotting line often used is the GTLN. At times, the observer may have to request ranging rounds to determine the GTLN. If so, the request for ranging rounds is announced in the distribution element of the call for fire. Ranging rounds will be fired 400 meters apart on the GTLN. If no direction is announced by the observer, the FDC will make subsequent corrections in relation to the GTLN.

2. The aircraft heading indicator will provide accurate direction in most cases. If the aircraft assumes a head-on posture, the reading on the heading indicator would indicate the observer target (OT) line. The OT direction is announced to the nearest 1° and is corrected if the OT direction changes by more than 10°. When making changes or subsequent corrections, ensure the corrections are in relation to the new OT direction. When using the heading indicator the observer should indicate that the direction is magnetic to avoid confusion.

3. If the aerial observer desires to use a cardinal direction as the spotting line, he may send the direction in mils to the FDC (e.g., West = 4,800).

4. The observer may select a terrain feature in the target area to be used as a spotting line. A road, railroad, or series of objects may be used. In any case, the direction of the reference line must be known by the FDC.

10.4.12.2 Target Location. Since an aerial observer is constantly moving, the polar plot method is rarely used by the air observer. If grid coordinates or shift from a known point is used, the procedures are the same as those for the ground observer.

10.4.12.3 Adjustments. Adjustments of subsequent round differ for an AO in that he may use a bracketing method for deviation as well as range.

Estimation of height of burst by an air observer is very difficult. However, if time fire is necessary, the air observer can attempt to distinguish between air-bursts and graze bursts to adjust a zero height of burst. If area time fire is required, a zero height must be established, followed by a correction of "UP 20" before fire for effect is entered. Normally, time fuze will not be employed if the mission can be accomplished with quick or VT fuze.

Other aids to the AO include the use of "AT MY COMMAND" in the method of control element of the call for fire. Additionally, the FDC will send "TIME OF FLIGHT" after the message to observer. This will ensure the observer is in a position to observe the rounds and make appropriate corrections.

10.4.12.3.1 Pop-Up Spotting. Because of the high-threat scenarios the OV-10 will likely face, conventional artillery airspot will sometimes be impossible to conduct. Utilizing the pop-up method of spotting will enhance the survivability of the OV-10 aircrew. Using paragraph 10.4.6.5, Method of Engagement, the aircrew will announce their intentions to the FDC that they will be adjusting from a "LINE OF KNOWN DIRECTION" or "CARDINAL HEADING." This technique requires the observer to use "AT MY COMMAND" as the method of control announced in the call for fire. Standing off and flying at low level, the aircrew, upon hearing that the artillery is ready, moves to an observation point, and while inbound gives the fire command. When the "SPLASH" is received, the aircraft will pop for a visual of the target area, and before descending an adjustment will be passed to the FDC.

10.4.12.3.2 Forward-Looking Infrared (FLIR). The FLIR adds a dimension to artillery adjustment never before available. Not only will it allow the aerial observer to detect and attack targets at night without illumination, it also aids in target location during periods of reduced visibility due to smoke, haze, or fog.

10.5 NAVAL GUNFIRE SUPPORT

Naval gunfire plays a vital role in fire support of landing force operations. The basic task of naval gunfire support units in an amphibious operation is to support the assault of the objective by destroying or neutralizing:

1. Shore installations that oppose the approach of ships and aircraft.

2. Defenses that may oppose the landing force.

3. Defenses that may oppose the post landing advance of the landing force.

The threefold mission of naval gunfire is accomplished in three phases. Specific tasks are carried out in each of these phases.

1. Pre-D-day fires are delivered by the advance force or in supporting operations. The primary mission of the advance force is to destroy enemy batteries and other installations capable of interfering with air, naval, and landing force operations in the objective area. Support is also provided for underwater demolition, reconnaissance, and mine warfare operations. Finally, these fires may include neutralization fires and fires necessary to isolate the objective area. Pre-D-day fires are best characterized as destruction fires.

2. D-day fires will probably force operations and are planned if there is a requirement not to fire a large volume of fire into the objective area prior to D-day. The main emphasis on D-day, however, is neutralization fires. A requirement to neutralize landing beaches, landing zones, and perhaps approach and retirement lanes may exist. Movement to the beach and off the beach must also be supported. This will be done by providing prearranged close and deep supporting fires. These are scheduled fires delivered to support landing force movement ashore until naval gunfire spotters become established ashore. Close supporting fires are based on the assumed rate of movement of the troops. Deep supporting fires are designed to destroy or neutralize targets away from the immediate vicinity of friendly forces in which known or suspected targets are located, especially indirect fire systems. D-day fires are best characterized as neutralization fires.

3. The Post-H-hour phase of naval gunfire commences as the scheduled fires cease. This occurs when direct support ships begin to receive requests for fire from supported units. During this stage of the operation, naval gunfire responds primarily to landing force requests. This phase terminates either when all gunfire support ships are out of range or the amphibious task force (ATF) is dissolved, whichever occurs first.

10.5.1 Capabilities and Limitations of Naval Gunfire. Naval gunfire has characteristics, some of which are unique, in the role it plays in supporting the landing force. To effectively use naval gunfire support,

you must understand the capabilities and limitations of the system.

10.5.1.1 Capabilities

1. Caliber of guns — 5- and 16-inch guns are available. This will provide an adequate selection of guns of varying capabilities to best accomplish the mission.

2. Ammunition — the different types of projectiles, charges (full and reduced), and fuzes available for each caliber permit selection of the optimum combination. No nuclear round presently exists for the naval gun. Laser-guided projectiles are in various stages of development.

3. Rates of fire — the relatively high rate of fire permits a large volume of fire to be delivered against a target in a short period of time. A large number of rounds on a target in a short period of time has a greater effect than the same number of rounds over a longer period.

4. High initial velocity — the high initial velocity of the projectile makes it suitable for penetrating material targets, particularly those presenting a vertical face on the gun-target line.

5. Flat trajectory — the relatively flat trajectory of the naval projectile increases accuracy and effectiveness in the attack of targets presenting a face vertical to the gun-target level.

6. Deflection pattern — the normal deflection pattern is very narrow. This pattern enables close supporting fires to be delivered to the front lines provided the gun-target line is parallel to the front lines. The pattern also permits effective coverage of targets such as roads, runways, etc., when the gun-target line coincides with their long axis. A narrow deflection pattern is a characteristic of all gun systems.

7. Fire control equipment — automated fire control permits accurate fire at anchor or underway. Optical and electronic equipments are available to permit direct fire by the ship.

8. Mobility — within the construction imposed by hydrographic conditions, the firing ship can be placed not only to best support the force, but also to permit maneuver to evade shore fire or other enemy attack means.

9. Ammunition replacement — provisions are normally made to replenish ships in the angle of attack (AOA), thus allowing a quick return to action.

10.5.1.2 Limitations. In addition to the capabilities, all users of a weapons system must have a working knowledge of its limitations to employ the system with a high degree of effectiveness. Naval gunfire is no exception.

1. Flat trajectory — this characteristic makes delivery of fire on targets in defilade difficult. Opening the gun-target range or the use of reduced charge may diminish this limitation by raising the trajectory, thereby increasing the angle of fall of the shell.

2. Communications — all communications between the ship and the shore are by radio. Because of this single means, NGF communications are susceptible to various interruptions. Also, since the ship and the spotter are constantly moving, communications may be degraded. Alternate radio nets may be required.

3. Fixing ship's position — the difficulty of accurately determining the exact position of the ship under adverse navigating conditions may result in inaccuracies of the initial salvo of indirect fire. The use of the radar beacon or a reference point identifiable by both the ship and spotter will increase the accuracy of fixing the ship's position.

4. Changing gun-target line — when the ship is firing while underway, the gun-target line will change. This may create an unsafe condition when firing in close proximity to the frontlines. This limitation may be offset by restricting the movement of the firing ship.

5. Effect of hydrography — water depth can determine NGF's maximum range inland. Reefs, shoals, mines, etc., may require the ship to take an unfavorable firing position. The officer commanding the ship or ships will make the final determination as to the distance off the beach that the ships will position themselves.

6. Effect of weather and visibility — heavy weather may force the gunfire ships to temporarily leave the objective area. Reduction in visibility has an adverse effect on the acquisition of, and adjustment of, fire onto targets.

7. Range pattern — the range pattern is relatively long. It may be as much as four times the deflection pattern. When firing perpendicular to the frontlines, an unsafe condition may result. Through mobility,

an unsafe condition may result. Through mobility, this may be turned to an advantage when attacking long and narrow targets along the gun target line.

8. Magazine capacity — ammunition capacity is limited. In addition, a reserve for the ship's defense must be retained. This limitation is partially offset by providing ammunition replenishment in the AOA.

9. Effects of enemy air or naval attack — enemy attacks may cause a complete cessation of support by requiring the fire support ships to engage this threat.

As you can see, certain capabilities in some circumstances become limitations and vice versa. The spotter with a little forethought should be able to take maximum advantage of his naval gunfire support.

10.5.2 Naval Gunfire Support Missions. NGF support ships are assigned one of two support missions; direct or general support.

1. Direct support — when a ship is assigned the mission of direct support, he will fire into her zone of fire, which corresponds to the zone of action of the supported unit. In naval gunfire, the mission of direct support connotes a destroyer firing in support of a committed infantry battalion. As the number of gun cruisers diminishes, destroyers will also be assigned the mission of general support. Further, helicopterborne units heretofore supported by cruisers because of range requirements will now have to be supported by destroyers (probably longer range 5"/54).

2. General support — in naval gunfire, the mission of general support connotes a ship in support of a regiment (not anticipated being held in reserve), division, or higher headquarters. The zone of fire for general support ships should be within the boundaries of the supported unit. Remember that destroyers may well be assigned the mission of general support if the situation and availability of ships so dictate.

There are some fundamental differences between the use of the words direct and general support as they relate to artillery and naval gunfire. Direct support in artillery connotes an artillery battalion in support of an infantry regiment. Direct support in naval gunfire implies a ship in support of an infantry battalion. In artillery, general support connotes an artillery unit in support of a division or the landing force as a whole. In naval gunfire, general support connotes a ship in support of a ground combat element (regiment or division).

The planner will be dealing primarily with the two different types of 5- and 16-inch weapons. Because the general support ships will have a requirement to cover a larger area by fire, range becomes a major determinant in the assignment of missions.

10.5.3 Naval Guns and Ammunition. Ships in the active fleet are currently armed with a variety of guns, all of which are mission oriented. The gunfire support ships (or combatants) are armed with guns ranging from 3"/50 up through the 16"/50 calibers.

The 3"/50 is primarily an AAW weapon and is not suitable in a gunfire support role due to limited range and shell size. All computations used in targeting naval gunfire are based on the effectiveness of the 5"/38. The 5"/54 with a larger shell, greater range, and higher rate of fire is replacing the 5"/38. The 6"/47 is found only on older cruisers. The 6"/47 guns have no significant air defense capability.

In discussing naval guns, the terms 5"/38 and 5"/54 refer to the diameter of the bore and the length of the tube in calibers. For example, 5" means the bore has a diameter of 5 inches and 38 means that the tube is 38 calibers long or 38 X 5 inches = 190 inches long (one caliber = one bore diameter). The range capability of a gun is determined, to a great extent, by the tube length.

10.5.3.1 Characteristics of Naval Guns and Ammunition. Figure 10-12 presents the characteristics of all current types of naval guns, including maximum and effective ranges, and projectiles available.

The large-range errors inherent in low-trajectory fire make a careful study of the terrain essential. This is especially true of missions fired close to friendly lines. At average ranges, the following minimum safety distances from troops should be observed (data in yards):

Cal.	Parallel to Front Lines	Not Parallel to Front Lines	Unobserved or Initial
5"	200	350	750
6"	250	450	1,000
16"	N/A	2,000	2,000

GUNS	ROUND	MAX. RANGE (YDS)	EFFECTIVE RANGE (YDS)	MAX. SUMMIT (FEET)	BURSTING RADIUS (YDS)	RATE OF FIRE (RP GPM)
			FULL CHARGE			
5"/38	AAC	17,900	15,000	17,900	30	15
	HC	18,100	15,000	17,900	30	15
5"/54	HC	25,600	18,000	28,300	45	35
16"/50	HC	38,000		35,800	250	2
			REDUCED CHARGE			
5"/38	AAC	8,900	7,500		30	
5"/54	AAC	13,500	11,300		45	
			ROCKET ASSISTED PROJECTILE			
5"/38	HC	24,000	33,000		30	
5"/54	HC	30,000	30,000		45	

Note

1. The maximum horizontal range listed is computed using standard conditions and new barrels. Day to day maximum range will vary considerably depending upon bore wear and atmospheric conditions.

2. RAP ammunition is designed for use against light structures and personnel and has limited destructive capability due to only 3.3 pounds burster charge. Effectiveness is achieved through increased fragmentation from cast projectile body. Effective utilization of RAP ammunition requires that it be fired with fuze set in CVT mode. However, if tactics dictate use of PD functions fuzes should be set for a time greater than the actual time of flight vice on PD. Setting PD on CVT fuzes does not assure VT function is de-energized. Accuracy of RAP ammunition is one percent of range or 3 mils.

3. Minimum range is 18,000 yards.

4. Reserve status only are 6" and 8".

Figure 10-12. Naval Guns and Ammunition

Note

The minimum safety distance varies with range as shown in the following examples:

Range	Min Safe Distance
10,000	1,950
20,000	2,050
30,000	2,300

10.5.3.2 Naval Gunfire Support Ships. The data contained in the following paragraphs include selected characteristics concerning representative classes or various types of ships. Characteristics of individual ships within a class sometimes vary considerably. Detailed information about a particular ship or ships may be found in NWP 11-1, Missions and Characteristics of U.S. Navy Combatant Ships (U). The publication, Armament of Naval Vessels of the United States (1971 issue), contains a statement of installed and ultimate armament of major ordnance for all U.S. Navy vessels regardless of their fleet status. The preceding two publications are classified CONFIDENTIAL. A fairly comprehensive report of ship characteristics can be found in JANE'S Fighting Ships.

10.5.3.3 Ship Characteristics. The size and physical dimensions of a naval gunfire support ship directly affect its ability to maneuver. They also determine its ammunition stowage capacity. The draft of the ship is a consideration in how close to the shoreline it may be positioned. The nature of the ship's gun fire control system determines the number of indirect fire missions which can be conducted simultaneously.

To properly employ a support ship, the planner must know not only the class of ship involved, but also the amount of ammunition available for the supported unit. To determine ammunition availability, the planner should establish liaison with the commanding officer of the supporting ship. If liaison is not possible, the planner may consult NWP 11-1 to determine accurate ammunition figures.

10.5.4 Naval Gunfire Communications. Communication annexes to the amphibious task force, advance force, and landing force operation orders will show the callsigns, frequencies, code names, instructions concerning use of voice radio security devices, and other special instructions pertaining to the radio nets to be used.

ATF naval gunfire support nets most commonly used may be found in NWP 22-2.

There are five landing force naval gunfire communications nets used when one division is employed.

1. The division naval gunfire support net is guarded by and provides radio communication among the division naval gunfire officer (NGFO), naval gunfire liaison officers (NGFLOs) of supported regiments, and ships in general support of the regiments and division. It is used for day-to-day NGF support planning. It is also used by the regiments to request NGF air spotters, additional NGF support, and by the regiments and division to assign missions to general support ships.

2. The division radar beacon provides radio communications between division naval gunfire officer and each radar beacon team.

3. The naval gunfire ground spot net provides communications between the spot team and the direct support ship. The NGFO at the battalion monitors and is normally in net control. One frequency is allocated to each infantry battalion assigned a direct support ship. If a general support ship is assigned a mission in support of the infantry battalion, it will enter the naval gunfire ground spot net of that unit for that mission.

4. The naval gunfire air spot net is used when missions are spotted from the air. The aerial observer talks directly to the direct or general support ship. When required, the NGFO is at battalion and regiment, and the division NGFO, as well as the spot team, may enter this net.

5. The shore fire control party local net provides a direct link between the battalion NGFO and his spot team. This net is primarily used for administrative purposes. If it becomes necessary, the spot team may send missions over this net to the NGFO who will pass the request to the ship on the NGF ground spot net which he monitors in the battalion FSCC.

10.5.5 Landing Force Organization for Naval Gunfire Support. At each level of the landing force down to the committed infantry battalion, there are naval gunfire personnel assigned. (See Figure 10-13.)

10.5.5.1 Naval Gunfire Section, Ground Combat Element, MAGTF. The composition of this section will depend upon the size of the ground combat element of the MAGTF.

10.5.5.2 Naval Gunfire Section, Marine Division. At division level, the NGF section is headed by a lieutenant colonel and he is assisted by a Navy lieutenant commander and enlisted Marines who provide operatio-

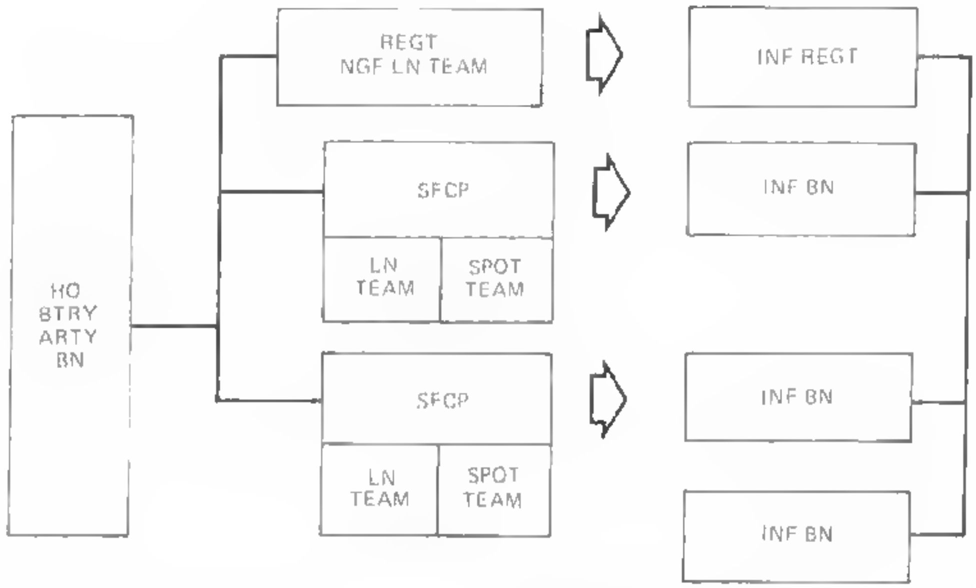


Figure 10-13. NGF Personnel for an Infancy Regiment (Assignments as Directed by CO Infantry Regiment)

nal and communications assistance. The section keeps the commander advised of NGF matters, coordinates NGF in the division FSCC, employs the radar beacons, and prepares the division NGF support plan.

10.5.5.3 Naval Gunfire Officer, Artillery Regimental Headquarters. Within the artillery regimental headquarters battery a Navy lieutenant commander serves as the naval gunfire officer. He coordinates the training of the shore fire control parties in garrison and he can provide assistance to the division NGF section in operational planning, manning in the FSCC, or serving as the NGF officer in the alternate command post.

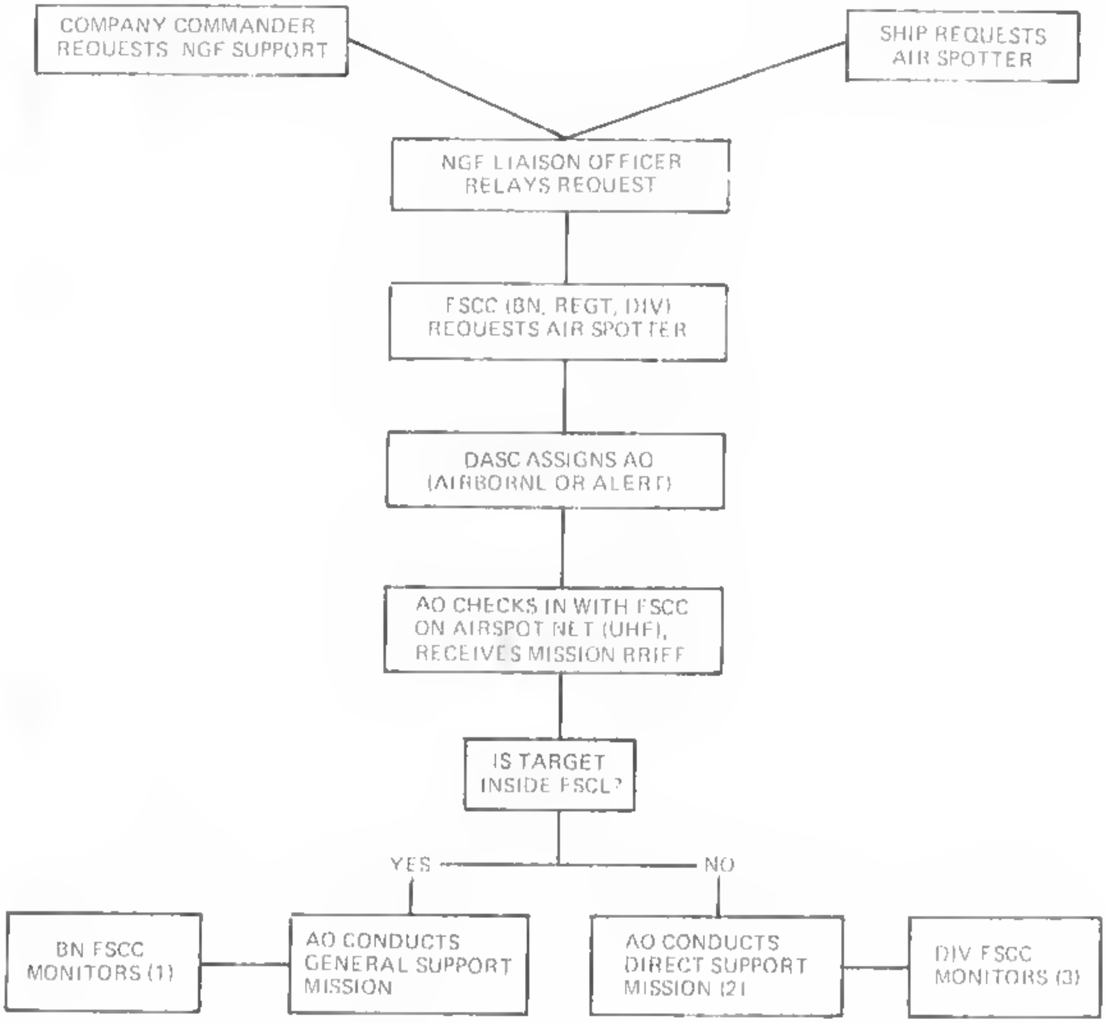
10.5.5.4 Regimental and Battalion Naval Gunfire Teams. At infantry regimental and battalion levels, the naval gunfire personnel are provided by the direct support artillery battalion. Each battalion of the artillery regiment has a regimental naval gunfire liaison team and two shore fire control parties (SFCPs) in its headquarters battery.

The regimental NGF liaison team is headed by a Navy lieutenant (NGF liaison officer) who has six enlisted Marine assistants. This team operates at the infantry regimental FSCC and advises the regimental commander on gunfire matters. Further, the team coordinates the firing of gunfire ship(s) in general support of the regiment. The NGF liaison officer supervises the operations of the two shore fire control parties operating with the battalions.

The SFCP is comprised of two teams. The first is the NGF liaison team, consisting of one Navy lieutenant (jg), the NGF liaison officer, and six enlisted Marines. One of the enlisted men serves as NGF chief while the rest are communicators. This team is assigned to the infantry battalion and utilized as special staff representation in naval gunfire matters for the infantry battalion commander. This team is under the staff cognizance of the infantry battalion S-3.

The second team of the SFCP is the NGF spot team. The spot team is headed by a Marine lieutenant who is assisted by six enlisted Marines (an NGF chief, shore-fire control partymen, and communicators). This team requests and adjusts gunfire for the battalion, either from a battalion observation post or company observation post, the battalion commander deciding with which company the team will operate. For short periods of time, the spot team could be split into two sections to provide an additional spot capability for the battalion. If required, artillery forward observers may function as NGF spotters.

10.5.5.5 Naval Gunfire Support Request. Though different radio nets are used, the sequence of obtaining naval gunfire support, as dipicted in Figure 10-14, is similar to that used for artillery. There is one significant difference, however, in that a ship, unlike a



Notes:

1. Although silence indicates consent, clearance shall be confirmed with controlling NGF Liaison Officer (Bn FSCC) prior to firing direct support missions whenever reliability of communications is questionable.
2. To obtain current target and friendly information during the conduct of the mission, the AO may contact the NGF spotter (usually with the company commander) and the battalion FSCC on the Shore-fire control party (local) net.
3. Silence indicates consent to fire the mission.

Figure 10-14. Naval Gunfire Airspot Mission Flow Chart

battery, does not directly confirm its clearance to fire with the FSCC. Clearance is based on the consent of the Naval Gunfire Liaison Officer, indicated by silence. This places additional responsibility on the air spotter to insure that clearance has been granted and that friendly troops are notified just prior to commencing fire.

10.5.6 Naval Gunfire Call for Fire. The call for fire for NGFS is essentially the same as the artillery call for fire (Figure 10-15). It is transmitted directly from the air spotter to the NGFS ship and is monitored by the FSCC/SACC. The call for fire for NGFS is considered to be an order vice a request. As with the artillery call for fire, it is a highly formatted message that is divided into six elements which are sent, in two transmissions.

1. The first transmission contains the observer identification, the warning order and target number.

2. The second transmission contains the target location, target description, method of engagement, and the method of fire and control.

10.5.6.1 Observer Identification. The exchange of radio call signs (e.g., "E6W THIS IS THUNDER ...") are normally used to identify observers.

10.5.6.2 Warning Order and Target Number. Use the words "FIRE MISSION" followed by the correct target number for warning orders. Target numbers usually consist of two letters and four numbers (e.g., "... FIRE MISSION, TARGET NUMBER AC1202, OVER"). If a block of numbers is not assigned to the air spotter, he may use any sequential system to keep track of the targets fired (e.g., the air spotters first and last initials followed by the time of day using the 24-hour clock). However, a block of target numbers will normally be assigned for the air spotter.

10.5.6.3 Target Location. As far as the air spotter is concerned, there are two ways of locating a target for NGFS: by the grid method or by shift from a known point.

1. Grid — normally a six-digit grid will suffice. There should be a slight pause between the third and fourth number (e.g., "GRID PG563 731, ...").

2. Shift from a known point — as in artillery, the air spotter will have several known points in the target area. These points could be targets that have already been fired on, registration points, prominent terrain features, or prominent man-made objects. In any case, the shift or reference point must be known by both the air spotter and the NGFS ship. There are several steps used in locating a target by shift from a known point. These are:

   (a) Identify the known point to be used

   (b) Determine a lateral shift from the known point to the target along the observer target line (OTL).

   (c) Determine the range shift to the target along the OTL.

   (d) Determine the vertical shift. As NGF has such a flat trajectory, any shift over 5 meters should be passed.

   (e) Once the lateral shift is computed, it is announced to the NGFS ship to the nearest 100 yards (e.g., "SHIFT RP #1, LEFT 200, ADD 400, UP 100, DIRECTION 360 DEGREES MAGNETIC, ...").

The target "ALTITUDE" is also given to the NGFS ship by the air spotter under "TARGET LOCATION." "METERS" is a given.

The last piece of information the air spotter is required to pass under "TARGET LOCATION" is "DIRECTION." The direction is the OTL. It may be given in mils to the nearest 10 mils or in degrees (magnetic, true, or grid) to the nearest 1°. If gun-target line (GTL) is desired, the air spotter will just say "DIRECTION, GTL."

10.5.6.4 Target Description. Used to identify the target as to what it is, what it is doing, how it is protected, etc. Remember: intelligence analysts will use this information. Be accurate, but be brief.

10.5.6.5 Method of Engagement. The air spotter will indicate how he wants to attack the target by announcing the type of engagement, trajectory, and ammunition to be used.

1. Type of Engagement

   (a) Danger/danger close — "DANGER" is transmitted when friendly forces are within 750 to 2,000 yards of the target. "DANGER CLOSE" is transmitted when friendly forces are a specified distance from the target (e.g., 750 yards for 5", 1,000 yards for 6" to 8" guns, and 2,000 yards for 16" guns). The air spotter will state "DANGER CLOSE" followed by the direction and distance from the target to the nearest friendlies. This call is omitted if no factor.

NAVAL GUNFIRE CALL FOR FIRE

1. OBSERVER IDENTIFICATION: ____________________

2. WARNING ORDER   FIRE MISSION TARGET NO. ____________________

   OVER

3. TARGET LOCATION: ____________________

   (GRID COORDINATES, POLAR COORDINATES, SHIFT)

   a. ALTITUDE (METERS ONLY)

   b. DIRECTION (SPECIFY) ____________________

   (DEGREES, MILS, MAG, TRUE, GRIDS)

4. TARGET DESCRIPTION:

5. METHOD OF ENGAGEMENT.

   a. DANGER CLOSE (DIRECTION/DISTANCE) ____________________

   SEE NOTE 2

   b. PROJECTILE (OMIT IF HE) ____________________

   c. FUZE (OMIT IF Q) ____________________

6. METHOD OF FIRE AND CONTROL.

   a. NUMBER OF GUNS (OMIT IF ONE DESIRED) ____________________

   b. ARMAMENT (OMIT IF MAIN DESIRED) ____________________

   c. CONTROL ____________________

   (SPOTTER ADJUST, SHIP ADJUST, AMC, FFE, CANNOT OBSERVE)

   OVER -

EXAMPLE

1 B1 THIS IS H8C17
2 FIRE MISSION   TARGET NUMBER AG 1053, OVER
3 GRID 125647, ALTITUDE 210M, DIRECTION 300 DEGREES GRID.
4 20 TROOPS IN OPEN.
5 DANGER CLOSE SE 500, TIME IN EFFECT
6 SPOTTER ADJUST, OVER

Note

1. The target number is determined and announced by the air spotter for opportunity. For preplanned targets, the number comes from the target list of the fire plan.

2. Danger Close signifies a target 750-2000 yards from friendlies. This mandatory term is followed by a cardinal or inter-cardinal direction and distance in yards from the target to friendly troops. As in Artillery Air Spot, the "Creeping" method of adjustment will be utilized in the NGF danger close mission.

Figure 10-15. Naval Gunfire Call for Fire

(b) Neutralization/destruction/precision — omitted if "NEUTRALIZATION" is desired.

2. Trajectory — used by the air spotter to change the trajectory from "FULL CHARGE" (low angle) to "REDUCED CHARGE" (high angle) "REDUCED CHARGE" is used to attack targets in defilade. This call is omitted if "FULL CHARGE" is used.

3. Ammunition — used by the air spotter to change the standard adjusting and fire for effect projectile/fuze (HE/Q). Transmitted as two elements: projectile and fuze.

10.5.6.6 Method of Fire and Control. Used by the air spotter to indicate the number of guns and salvos to be fired in adjustment, the armament to be used, special instructions, and his desired method of control.

1. Number of guns — one gun, one salvo is understood unless otherwise requested.

2. Armament — used by the air spotter to identify which ship's armament he desires to use for the mission (i.e., "MAIN ARMAMENT" [largest caliber guns] or "SECONDARY" [smallest caliber guns]). "MAIN ARMAMENT" is assumed unless otherwise stated.

3. Special instructions — used by the air spotter, in a "DANGER CLOSE" mission, to tell the ship where he wants the first salvo to land (e.g., "...FIRST SALVO, ADD 400, LEFT 200, ...").

4. Method of control — used by the air spotter to indicate to the NGFS ship how he would like to control the mission (i.e., "SPOTTER ADJUST," "SHIP ADJUST," "CANNOT OBSERVE," or "FFE"). As with artillery, "AT MY COMMAND" should also be given by an air spotter.

10.5.6.6.1 Coordinated Illumination Mission. Figure 10-16 is an example illustrating the proper procedures for a coordinated illumination mission. Conserve illumination shells whenever possible, since ships have limited supplies of this type of ammunition.

10.5.6.7 Message to Observer (MTO). After the last transmission by the air spotter to the NGFS ship, and if the FSCC authorizes the mission, the NGFS ship will transmit the MTO to the air spotter. It should be in the following format:

1. Gun target line (GTL) — indicates to the air spotter on what bearing the guns will be pointing when the round is fired (given in degrees true) (e.g., "GTL 260 DEGREES TRUE, ...").

2. Ready/time of flight (TOF) — this indicates two things: that the ship is ready to fire the mission and what the time of flight is for the round in seconds (e.g., "...READY 15, ...").

3. First salvo intentions — the ship will pass this for "DANGER CLOSE" missions only (e.g., "...FIRST SALVO INTENTIONS NORTH-EAST 600, ...").

4. Summit — indicates to the air spotter what the max ord of the projectile is (e.g., "...SUMMIT 3,650 FEET").

5. Any changes or modifications to the air spotter's fire mission.

10.5.6.8 Report on Opening Fire. Both of these reports which follow are transmitted by the NGFS ship to the air spotter every time a salvo is fired until "FFE" is called for, at which time they will be passed only for the first salvo.

1. Shot — is transmitted when the first salvo is fired.

2. Splash Out — is transmitted 5 seconds before a salvo is due to detonate. The air spotter does not acknowledge "SHOT" or "SPLASH."

10.5.7 Shell/Fuze Combinations. Figure 10-17 provides guidelines for selection of appropriate projectiles and fuzes for various targets.

10.5.8 Naval Gunfire Adjustment Techniques. Adjusting NGF is the same as in artillery (LEFT/RIGHT, ADD/DROP, UP/DOWN).

10.5.9 "FIRE FOR EFFECT." This may be entered when a 200-yard range bracket has been split.

1. The air spotter will initiate "FFE" by announcing the number of guns and salvos desired in the effect. It is an executive order to fire what is requested without delay unless "AT MY COMMAND" has been requested (e.g., "TWO GUNS, TWELVE SALVOS, AT MY COMMAND, FFE, OVER").

2. ROUNDS COMPLETE: Is passed by the ship to report to the air spotter that all rounds requested for "FFE" have been fired. The air spotter must read back "ROUNDS COMPLETE, OUT."

ELEMENT	EXAMPLE
1 Spotter ID	"FAVOR THIS IS CHIPPEWA ONE NINER"
2 Warning Order	"FIRE MISSION, TARGET NUMBER ONE ONE NINER, OVER."
---BREAK FOR READBACK BY SHIP---	
3 Location	"GRID FOUR FOUR FOUR-SIX-SIX-SIX, ALTITUDE TWO-ZERO YARDS, BEARING GUN TARGET NINE,"
4. Description	"FOUR TRUCK CONVOY TRAVELING SOUTH,"
5 Method of Engagement	
(a) Type Adjustment	"DANGER CLOSE SOUTHWEST FIVE HUNDRED,"
(b) Trajectory	(Not applicable)
(c) Ammunition	"ILLUMINATION,"
6. Method of Fire and Control	
(a) Method of Fire	"ONE GUN"
(b) Method of Control	"PREPARE TO FIRE HIGH EXPLOSIVE AFTER ILLUMINATION ADJUSTMENT, ADJUST FIRE, OVER,"
---BREAK FOR READBACK BY SHIP---	
After Illumination Adjustment	
1. Spotter May Transmit	"CONTINUOUS ILLUMINATION, ILLUMINATION CHECK FIRE, HIGH EXPLOSIVE, FUZE QUICK, TWO GUNS, AT MY COMMAND, ADJUST FIRE, OVER."

---BREAK FOR READBACK BY SHIP---

2. After the ship transmits "HIGH EXPLOSIVE READY" report to spotter, the spotter would follow with "ILLUMINATION, CANCEL CHECK FIRE, OVER."

3. As soon as the target is properly lighted, the spotter would transmit (for example) "HIGH EXPLOSIVE, FIRE, CANCEL AT MY COMMAND, OVER."

4. Subsequently, the ship would continue firing illumination, while a normal adjustment and fire for effect mission would be conducted for the high explosive shells. Each correction/command must be prefaced by the shell to which it is to be applied.

5. The spotters command of "END OF MISSION," would terminate the illumination firing.

Figure 10-16. Typical Naval Gunfire Coordinated Illumination Mission

TARGET	SHIP'S GUNS	RECOMMENDED PROJECTILES AND FUZES
Heavy Concrete Fortifications	16 Inch	AP
	8 Inch & 6 Inch	AP
	5 Inch & Smaller	Not Recommended
Light Concrete Or Log And Earth Fortifications, Strong Masonry Buildings	16 Inch	HC (PDF)
	8 Inch	HC (Nose Plug)
	6 Inch & 3 Inch	AP Note 1
	5 Inch	COM Note 1
Dispersed Targets In Open, Such As Parked Aircraft, Vehicles, Personnel, Light Frame Buildings	16 Inch	HC PDF & Nose Plug
	8 Inch & Smaller	HC (PDF), AAC, Or VT Note 2
	5 Inch	HC (VTF, MTF Or PDF)
Large Targets Of Light Construction Such As Oil Tanks, Hangars, Factory Buildings.	16 Inch	HC (PDF 7 Nose Plug)
	8 Inch To 5 Inch	HC (PDF At Short Range, Nose Plug At Long Range)
Runways And Roads, Paved Or Unpaved.	ALL	HC (Nose Plug)

Notes:

1. Projectile not particularly effective against this target but is more effective than a non-delay fuzed projectile.

2. MTF should be set to obtain a low-level air burst. If height of burst can be accurately controlled, MTF will be preferable to PDF. At short ranges MTF is preferable to VT due to erratic functioning of VT at low angle of fall, VT fuzes employed in long-range bombardment must be NSD.

Figure 10-17. Projectile-Fuze Selection for Shore Targets

10.5.10 Sequence of Subsequent Corrections. Same as for artillery (Figure 10-18).

10.5.11 Orders to Terminate Firing

1. End of mission — is given by the air spotter and is followed by the damage assessment. Must be given to terminate a fire mission.

2. Record as target — is given BEFORE end of mission is transmitted. Lets the NGFS ship know that the air spotter would like to possibly use the target to SHIFT from at a later date.

3. Will not fire — is given by the NGFS ship for safety or other reasons. Will terminate the present fire mission.

10.6 SUPPRESSION OF ENEMY AIR DEFENSE (SEAD)

The OV-10 crew has a significant role in the coordination and control of SEAD fires in support of both offensive air and assault support operations. The multimission capability, coupled with the team concept and a variety of communications equipment, gives the OV-10 crew the potential to coordinate and control artillery, naval gunfire, mortars, attack helicopters, strike aircraft, and EW assets through

	SPOT	CORRECTION	EXPLANATION
1	Air	"Down"	An appropriate amount to result in a 20-yard height of burst (5", 6", and 8")
2.	Graze	"Up 40"	If short of target, range is doubtful and no range change can be made
3	Mixed (or previous Air Burst in Mission)	"Up 20"	Yards are always understood when making corrections
4	Mixed Air	No Height Correction	Height of burst assumed to be correct.

Figure 10-18. Corrections for Timed Fire

close and continuous coordination with ground and air control agencies such as the FSCC or DASC.

10.6.1 SEAD Techniques. The term SEAD is all encompassing in that it requires the use of all available techniques to aid in reducing the vulnerability of our aircraft to the hostile threat. Our SEAD techniques must target not only surface to air missiles (SAMs) and anti-aircraft artillery (AAA) but also hostile antiair warfare (fighters) assets. It will require integrated use of both aviation and ground assets in a coordinated effort involving both passive and active suppression and defensive measures. In future conflicts, effective SEAD may become a prerequisite to successful CAS and assault support operations. The SEAD techniques to be considered include, but are not limited to, the following:

1. Aircraft self-defense/protection equipment such as radar warning and receiver (RWR) gear, chaff and flare dispensers, onboard jammers, and other ECM and ECCM suits plays an important role in the survivability of modern aircraft. Much of this equipment is designed to confuse or deceive enemy radars or guided missiles.

2. Avoidance tactics such as low-level high-speed ingress, TERF, evasive maneuvers, and pop-up loft, or other standoff delivery techniques aid in aircraft survivability because of the reduced exposure to the hostile threat and the decreased probability of early detection by surveillance, acquisition, and tracking radars. The OV-10 aircraft should not fly into a threat if it can be avoided by flying a particular route or altitude.

3. ECM including standoff or escort jamming with the EA-6B may aid aircraft in reaching the target area undetected. Communications jamming must also be used to disrupt the enemy's command and control systems.

4. Saturation tactics with large numbers of strike aircraft may aid in the attack of a highly defended or high priority target.

5. If detected and attacked by hostile aircraft, evasive maneuvers and self- defense with organic weapons may be necessary. However, escort with fighter aircraft, MIG sweeps, and CAPS are AAW/SEAD tactics that may allow our strike aircraft or helicopters to continue to the target area while our fighters tie up the hostile air threat. In any event good look-out doctrine and mutual support will be essential.

6. Fighters along with the HAWK and STINGER, through integration with command and control agencies, combine to form our own integrated AAW defenses that may allow our attack aircraft and helicopters to accomplish their missions without the prohibitive interference from a hostile air threat.

7. If infrared missiles present a threat to our aircraft, artillery and naval gunfire illumination flares may be delivered over the target area, particularly the egress route, to confuse the acquisition and homing mechanisms of the heat seekers.

8. Destroy enemy air defenses with accurate fire from direct and indirect fire sources (artillery, naval gunfire, fixed-wing aircraft, attack helicopters, tanks, etc.). If these fires are to be effective, the targets must be accurately located. This is very difficult in a rapidly moving combat environment considering the mobility of most of the threat AAW systems. We can ill afford to expend large amounts of ordnance saturating a large area in hopes of suppressing a suspected or potential target. A large variety of ordnance is available from both air and surface delivery systems that is effective against

most AAW systems. ARM, LGB, CBU, Mk 80 series HE bombs, and rockets are some of the most effective antipersonnel/antimaterial ordnance available. HWE, ICM, or WP may also prove to be quite effective against accurately located targets. All aircrews have a visual reconnaissance mission, and it must be stressed that all information regarding hostile AAW systems be reported upon return from each mission so the intelligence community can disseminate this information.

9. Suppress the enemy's ability to acquire and attack our aircraft through electronic interference and the use of smoke screens. Although not lethal, smoke (HC or WP) is effective as part of the SEAD plan because it reduces the enemy's ability to acquire our aircraft through visual means. This enables systems without radars to use their radar/automatic modes, thus making them more vulnerable to ARMs and ECM. Smoke may inhibit friendly forces also, so use it carefully and only with the approval of the commander (or his designated representative in the FSCC) in whose zone of action you are working. A large amount of smoke in the target area may make it difficult for attack pilots to identify the target or the target mark and reduces your ability to use lasers and LGBs. The FLIR does have some capability to see through smoke and haze.

10.6.2 SEAD Employment Considerations. The emphasis placed on SEAD fires by the maneuver unit will generally be a function of unit SOP, since little formal guidance exists. The commander must set policy and establish priorities so planners in the FSCC have a solid foundation from which an effective SEAD plan can be derived. Many factors must be taken into consideration in the decision to employ SEAD fires from surface delivered sources.

1. The nature and extent will have a large impact on how much SEAD is required. Low- or middle-threat environments or attrition of hostile AAW systems through combat losses will drastically reduce the amount of SEAD required.

2. Adequate time to prepare and coordinate SEAD fires is mandatory. Preplanned missions normally offer the most time to plan, compute, disseminate, and coordinate SEAD fire plans. Due to the many technical gunnery problems and the complexities of disseminating SEAD fire planning information, it is very difficult to provide effective SEAD fires for on-call or immediate air support missions.

3. Artillery survival tactics must be given consideration in the decision to employ SEAD fires. If an artillery unit fires the large quantity ammunition expected during a SEAD mission, the chances of that unit's firing position(s) being detected by enemy target acquisition assets is quite high. The threat of counterbattery fires may necessitate frequent moves on behalf of supporting artillery and mortars. Current tactics employed by most artillery units are designed to reduce the probability of detection by hostile target acquisition assets regardless of the type of mission fired. Generally speaking, spreading the mission throughout several firing batteries reduces the effectiveness of the enemy counterbattery radars, but it is difficult and time consuming to coordinate and may override other missions. This threat to the commander's organic fire support assets is real and must be considered in the decision to employ SEAD fires.

4. SEAD fires consume large amounts of ammunition. When ammunition supplies become critically short we may not be able to afford the luxury of SEAD fires. In future conflicts we expect to see a target rich environment. The quantities of ammunition required to attack these targets will put a significant dent in the ammunition supplies of the artillery and will strain the logistics channels to keep the artillery supplied. Rationing of artillery ammunition may require that only high priority targets be attacked.

5. Target priorities must be established by the maneuver commander. Generally, unit SOP or operation orders will set down the commander's policy on target priority. These documents are used by the FSCC as a basis for attack guidance and target selection. The types of targets that SEAD will have to compete with for priority include, but are not limited to, enemy armor, artillery, mortars, observation posts, communications jammers, and ground forces in contact.

6. Most targeting information is coordinated and disseminated in the maneuver unit S-2, COC, or FSCC. In some cases, however, the observer has better information regarding a hostile air threat in a particular area of the battlefield than the S-2. If the OV-10 crew identifies targets that may present a hazard to attacking aircraft, those targets may be attacked immediately rather than waiting until attacking aircraft are in their attack profile. These highly mobile systems may not remain in the same position long enough to effectively locate or target later.

7. Timing is a critical element of an effective SEAD mission. The number of agencies involved with executing a preplanned mission may be such

that the schedule will be very inflexible and changes will not have time to filter through to all agencies involved. This problem may also exist if we are forced to operate in a high communications jamming environment. If the mission is the result of an immediate air support request, control and coordination must be handled at very low echelons. Generally, the responsibility for coordination of a CAS mission will rest with the terminal controllers. If SEAD or marking rounds are delivered by artillery or mortars, sufficient time must exist to allow the artillery to make the computations, and a time hack or time to target (TTT) must be coordinated between the attack aircraft and the artillery. The OV-10 crew must be capable of providing this critical link by performing both as FAC and FO.

8. Target marking has been identified as a requirement for effective CAS. When artillery units are designated to fire target marks, their ability to suppress targets is reduced. The observer must determine if artillery is the best system to provide the mark or if the mark would be more effective or practical coming from a FAC(A) firing WP rockets, a tank, or other supporting arm. Remember smoke and dust on the battlefield may make a WP mark difficult to see or identify.

9. All procedures for ensuring safety of friendly troops, aircraft, and equipment must be considered in the execution of SEAD fires. With regard to aircraft safety, peacetime safety restraints may require the careful scrutiny of supporting fires in conjunction with CAS strikes. Sophisticated combat situations may require continuous fires into the target area. Continuous fires from artillery, naval gunfire, or mortars may cause some concern, but aircrews must remember that friendly rounds in flight not aimed at the aircraft constitute a remote hazard and a lesser threat to our aircraft than aimed, unimpeded enemy AAW fires.

10. The use of restrictive fire support coordination measures such as formal ACAs should be avoided, due to the loss of surface delivered fires that result. The FSCCs at various levels of command provide a means of coordination that will preclude the necessity for using ACAs.

10.6.3 General. Regardless of what suppression technique is employed, the goal must always be the same. It must provide local air superiority at a specific time and place in order to prevent the enemy from providing interference that would prohibit the use of our aircraft in the CAS role. The most effective techniques may not be those that are intended to destroy the targets but rather those that will render the enemy's air defenses ineffective during the critical time when the CAS aircraft are most vulnerable. Through careful and integrated use of all suppression techniques previously discussed, the threat AAW systems will be neutralized to the extent that allows us to conduct CAS with a high degree of effectiveness and reduce our combat losses in the high-threat, sophisticated battlefield of the future. The most effective suppression technique yet may prove to be ground attack by infantry and armor units.

10.6.4 SEAD Call for Fire. If, in your estimation, SEAD or marking rounds from artillery are required in conjunction with a CAS mission, a SEAD call for fire must be initiated. When you contact the FDC with your call for fire, identify whether a mark, SEAD, or both are required. Any known or very likely targets to be suppressed must be identified, or the FSCC (who is monitoring your request) will assign targets to be attacked if the need exists. Since timing is critical for this type of mission, the observer must assign the mission a time to target or make it *AT MY COMMAND* is the method of control element of the call for fire. If the mission is *AT MY COMMAND* you must know the time of flight of the artillery projectile in order to determine the proper time for the SEAD or mark to be fired. Additional information may also be necessary in order to ensure aircraft safety. Dictating offsets from ingress heading, pulloff directions, egress directions, and maximum or minimum altitudes as part of the CAS brief will assist the terminal controller in coordinating the SEAD fires on targets that present the most significant threat to our CAS aircraft. Passing this information as part of the artillery call for fire (CFF), or in addition to the CFF, will also aid the artillery in planning fires along and around the flightpath of the attacking aircraft. In effect, coordination between the FAC(A) and the FDC, in conjunction with the FSCC, has established an informal ACA by allowing attack aircraft and artillery or mortars to engage the same target or targets in close proximity simultaneously. It is important for the attack aircraft to fly the designated route for several reasons. The route will be picked to allow the aircraft the largest margin for safety by avoiding certain known threats. It is also picked based on the ability of the surface delivery systems to provide SEAD fires in those areas. By dictating offsets, the FAC(A) aids the attack pilot in target acquisition or ability to attack a particular target. This is especially true if the target is located in defilade, against hills or mountains, or in ravines, etc. Several general procedures have been used for coordination of SEAD fires. Most unit SOPs will employ a variation of one or more of these techniques.

Regardless of the SEAD technique used, the CFF sent to the FDC must be concise and in a form that is easily understood. However, because CFF and SEAD target marking rounds are unique in several ways, spe-

eral procedures may be utilized. The observer must be familiar with the FDC procedures of the artillery unit he is working with and the unit SOP as it deals with SEAD, or target marking for CAS. Examples of CFF that may be appropriate (based on local SOP) are given in Figure 10-19.

Notice that in the second example (Figure 10-19), the terms continuous and discontinuous suppression are used in the explanatory remarks. These terms mean that suppressive fires will either be delivered continuously during the aircrafts attack, or will temporarily cease for a short period of time while the aircraft are executing their attacks. The specific CFF format, numbers and types of rounds to be fired, timing, and selection criteria will normally be delineated in unit SOPs, the Operation Plan/Order, and amplified by the commanders guidance. The decision as to whether SEAD should be continuous or discontinuous should be made by the terminal controller working in concert with the appropriate fire support coordination center. The decision making process will be based primarily on the need to suppress certain threat(s) balanced against protecting the attack aircraft that may be required to fly through the GTL and/or avoid the suppressive fire frag pattern.

10.6.4.1 Coordinated Fire Support Target (Lateral Separation). This method addresses two targets in close proximity. This tactic requires that the aircraft approach the target parallel to the artillery line of fire. The FAC must provide headings if applicable.

10.6.4.2 Coordinated Fire Support on Same Target (Altitude Separation). This tactic assumes that the targets are close to each other and that the artillery is firing low angle. Clearance from the artillery trajectory and fragmentation pattern is provided by

OV-10 (TRAP DOOR 110)	BTRY FDC (F7I)
"F7I THIS IS TRAP DOOR 110 FIRE FOR EFFECT SEAD, OVER." "SUPPRESS GRID AW780315, MARK GRID AW791436, OVER." "STANDBY, 6+00...HACK, OVER." "BACK DOOR AT MY COMMAND, OVER."	"THIS IS F7I, FIRE FOR EFFECT SEAD, OUT." "SUPPRESS GRID AW780315, MARK GRID AW791436, OUT." "ROGER, 6+00, OUT." "BACK DOOR AT YOUR COMMAND, OUT."
"F7I THIS IS TRAP DOOR 110, BUCKSHOT*, OVER." "LINE 1, AW791436, OVER." (TARGET TO BE MARKED) "LINE 2, AW780315, GREEN (OR RED), OVER." (GREEN SIGNIFIES CONTINUOUS SUPPRESSION.) "LINE 3, 1546 OVER." (1546 IS AIRCRAFT TIME ON TARGET)	"THIS IS F7I, BUCK SHOT, OUT." "LINE 1, AW791436, OUT." "LINE 2, AW780315, GREEN, OUT." (RED SIGNIFIES DISCONTINUOUS SUPPRESSION.) "LINE 3, 1546 OUT."
*BUCK SHOT IS A CHANGING CODEWORD THAT MEANS SEAD CALL FOR FIRE.	

Figure 10-19. Sample Artillery SEAD Calls for Fire

lateral separation and recovery altitude restrictions placed on the aircraft. Other restrictions which must be applied include no change in artillery trajectory; no overflight of the gun-target line, except at the impact point; aircraft attack headings within 15° of the artillery gun barrel line; and recovery above the artillery maximum ordinate if overflight cannot be avoided.

10.6.4.3 Coordinated Fire Support on Same Target (Timed Separation). This tactic requires artillery to be fired at specific time intervals determined by the ALO and the FSC. It can also be accomplished by having the FAC clear the artillery to fire each volley. Aircraft must then arrive over the target after artillery impact and within a specific time interval. Restrictions include no shifting of fires, arbitrarily agreed upon time intervals, radio procedures, and lost communications procedures to stop artillery or call off the aircraft. Timed separation obviously lends itself to the other restrictive plans mentioned in this discussion.

10.6.4.4 Coordinated Fire Support on Adjacent Targets (Altitude and Lateral Separation). This is the most restrictive of all the plans since both vertical and horizontal separation are required. It is important to note that this plan provides suppression of enemy air defenses by artillery and the enemy AAA position. Vertical restrictions are accomplished by assigning a maximum altitude over the target for the attack aircraft which is below the gun line. The FAC and FO must coordinate the gun lines, maximum ordinate altitudes of the artillery, maximum altitude of the aircraft, and provide a restricted aircraft run in line.

10.7 CLOSE AIR SUPPORT (CAS)

When artillery and naval gunfire are inappropriate or out of range, targets are neutralized or destroyed by strike aircraft. Close air support refers to air attacks against hostile targets in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces. The commander of the supported ground unit must approve all close air support missions in his area of responsibility. Deep air support missions require no coordination with friendly ground units and generally will not be controlled from an OV-10. The following paragraphs deal with the planning and procedures required to conduct close air support. For a general discussion of the capabilities and limitations of CAS, refer to FMFM 5-1, Chapter 1 and FMFM 5-41.

10.7.1 Categories of CAS Missions

10.7.1.1 Preplanned CAS. Preplanned CAS is CAS anticipated sufficiently in advance to permit detailed mission coordination and planning. Preplanned CAS may be categorized as:

1. Scheduled mission — CAS strike on a preplanned target at a preplanned time (TOT).

2. On-call mission — CAS strike on a preplanned target or target area, executed when requested by the supported unit. Usually launched from a ground alert ("SCRAMBLE") but may be flown from an airborne alert status.

10.7.1.2 Immediate CAS. A CAS strike not previously anticipated or planned for is immediate CAS. Usually these missions will be flown utilizing assets that were scheduled for other missions. Response time is critical; therefore, aircraft will usually be launched/diverted and en route before mission coordination can take place.

10.7.2 Strike Aircraft Capabilities. With a thorough knowledge of the capabilities of the aircraft, the FAC(A) or FAC will control who is essential to the success of his mission. Figure 10-20 depicts the communication, navigation, and ordnance and capabilities of attack aircraft.

The systems available on each of these aircraft have a measurable effect on the circular error probable (CEP) of the delivery, and this in turn affects the number of sorties required to neutralize or destroy the target. The classified Joint Munitions Effectiveness Manuals (JMEM, FMFM 5-2 series) provide average CEPs for specific weapons and aircraft systems. The TAC(A) and FAC(A) should have a general knowledge of this material, but must also use his own experience to evaluate how weather, terrain, enemy defenses, and pilot skill will affect the data.

10.7.3 Airborne Ordnance Capabilities. The FAC(A) must also have a working knowledge of the types of aircraft ordnance available to him, how it works, and what its capabilities and limitations are.

10.7.3.1 Weapon Selection. Matching the appropriate weapon with the target is one of the key responsibilities of the TAC(A) and FAC(A). Appropriate selection improves the likelihood of an effective strike and precludes needless risk for both the aircrews and the supported ground unit. A general guide to weapon selection is found in Figure 10-21. For preplanned strikes, more detailed information is found in the JMEMs.

10.7.3.2 Minimum Safe Distances. The recommended minimum safe distances from friendly troops depicted in Figure 10-22 assume flat terrain. In

TYPE OF AIRCRAFT	COMMUNICATIONS	NAVIGATION	GUNS	CONVENTIONAL ORDNANCE		LASER EQUIPMENT	
				EXTERNAL	MAX LOAD	TRACKER	DESIGNATOR
A-4M	UHF VHF-FM	TACAN ADF	20 MM 400 ROUNDS	ALL	7,000 LBS	YES (ARBS)	NO
AV-8B	UHF UHF-AM VHF-FM	TACAN INS *NVGs *NAVFLIR	25 MM 300 ROUNDS	ALL EXCEPT MK 84, HARM AND WALLEYE	8,000 LBS	YES (ARBS)	NO
A-6E	2 UHF	TACAN ADF INS RADAR FLIR	NONE	ALL EXCEPT HARM AND MAVERICK	15,000 LBS	YES	YES
AH-1J	UHF VHF-FM	TACAN ADF FM HOMER RADAR BEACON	20 MM 750 ROUNDS	2.75 ROCKETS 5.0 ROCKETS FLARES FAE	1,500 LBS	NO	NO
AH-1T *AH-1W	UHF VHF-FM VHF-AM AH-1W	TACAN ADF FM HOMER RADAR BEACON	20 MM 750 ROUNDS	2.75 ROCKETS 5.0 ROCKETS FLARES FAE TOW MISSILES HELLFIRE	2,500 LBS	NO	NO
OV-10A	UHF 2 VHF-FM HF	TACAN ADF	7.62 MM 2,000 ROUNDS OR 20 MM POD	2.75 ROCKETS 5.0 ROCKETS FAE FLARES	3,600 LBS	NO	NO
OV-10D (+)	3 UHF/ VHF-AM/ VHF-FM HF	TACAN ADF DOPPLER	7.62 MM 2,000 ROUNDS OR 20 MM POD	2.75 ROCKETS 5.0 ROCKETS FAE FLARES	4,600 LBS	NO	YES
F/A-18 F/A-18D	UHF VHF-FM VHF-AM	TGT FLIR/NAV FLIR PODS TACAN ADF INS RADAR NVGS (F/A-18D)	20 MM 580 ROUNDS	ALL	13,700 LBS	YES (POD)	NO
A-7E	UHF	TACAN ADF INS RADAR	20 MM 1,019 ROUNDS	ALL	12,000 LBS	YES (POD)	NO
A-10	UHF VHF-AM VHF-FM	TACAN INS	30 MM 1,100 ROUNDS	ALL	16,000 LBS	YES (POD)	NO
AC-130 GUNSHIP	UHF VHF HF SATCOM	INS LORAN CID DOPPLER LLTV FLIR	2 X 20 MM 3,000 ROUNDS 40 MM 100 ROUNDS 105 MM HOW 100 ROUNDS	NONE		YES	YES

*AH-1W - COCKPIT HUD SYMBOLOGY WILL DEPICT WHERE HELLFIRE MISSILE IS LOOKING.

*AV-8B NIGHT ATTACK VARIENT.

Figure 10-20. Attack Aircraft Capability Chart

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
1 Personnel			
a In Open	Cluster Weapons With Fragmentation Bomblets Firebombs General Purpose Bombs H E Gun Projectiles	Instantaneous & V T	
b In Foxholes	Cluster Weapons With Fragmentation Bomblets Fuel Air Explosives General Purpose Bombs	V T	
c Under Light Cover	Cluster Weapons With Shaped-Charge Bomblets General Purpose Bombs Rocket Or Gun Projectiles With Armor Piercing Warheads	Short Delay	No Guided Weapons Due To Limited Signature
d Under Heavy Cover (Concrete Bunkers)	General Purpose Bombs Guided Weapons With Large Warheads	Long Delay	
2 Armored Vehicles (Tanks, APC's & Mobile Assault Guns)	Conical Shaped Charge (CSC) Weapons Electro Optically-Guided Bombs (EOGB's) General Purpose Bombs Guided Weapons With Linear Shaped Charge (LSC) Warheads LGBs Rockets With Armor Piercing	Instantaneous Or Short Delay	

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 1 of 7)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
3. Field Artillery			
a. In Open	Cluster Weapons With CSC Bomblets and Fragmentation Bomblets		Mainly Against Personnel and Crew
	EOGB's		
	General Purpose Bombs	Airburst	Mainly Against Personnel and Crew
	General Purpose Bombs	Instantaneous or Short Delay	
	Guided Weapons With Large LSC Warheads		
	LGB's		
	20MM API		
b. In Revetments	Cluster Weapons With CSC Bomblets		Mainly Against Personnel and Crew
	EOGB's		
	General Purpose Bombs	Instantaneous & V T	(Low Alt Detonation)
	Guided Weapons With Large Warheads		
	LGB's		
c. In Covered Positions	General Purpose Bombs	Delay	
	Guided Weapons With Large Warheads		
4. Anti Aircraft Artillery			
a. Automatic	Same as 3 With the Following Additions		Against Light Honeycomb Radar Vans
	Firebombs		
	20MM HEI		Against Off-Carriage Fire Control
b. Self Propelled	Same As 2		Some Are Open On Top And Are Susceptible To HEI Projectiles & Cluster Weapons With Shaped Charge Bomblets
5. Rocket Launchers	Cluster Weapons With CSC Bomblets	Instantaneous or V T	
	General Purpose Bombs		
	Guided Weapons With Large Warheads		

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 2 of 7)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
6 Missile Sites			
a SAM (Surface To-Air Missiles)	Anti Radiation Missiles Followed By Cluster Weapons With Frag Or Shaped-Charge Bomblets Or Retarded Bombs	Instantaneous	To Temporarily Disable Radar
	General Purpose Bombs	V T Instantaneous	(Delivered Inside Of Revetment)
b. SSM (Surface-To-Surface Missiles)	Same As 2 With The Following Changes/Additions:		
- Against Liquid Fueled Missiles	Cluster Weapons Followed By Incendiary Munitions Or Firebombs		
	General Purpose Bombs	Contact Fuzed	
	General Purpose Bombs	V T	(Low Altitude Burst)
- Against Solid Fueled Missiles	Cluster Weapons With Shaped Charge Bomblets EOGB's		
	General Purpose Bombs LGB's	Contact	
7 Radar Installations	Anti-Radiation Missiles		(If Target Is Radiating)
	Cluster Weapons With Fragmentation Or Shaped-Charge Bomblets EOGB's or LGB's With Fragmentation Or Shaped-Charge Bomblets Firebombs		Direct Hit Or Near Miss On Light Honeycomb Radar Van
	General Purpose Bombs 20mm	V.T & Instantaneous	Hit On Radar Van
8 Airfields			
a Parked Aircraft:			
– In Open, Uncovered Or In Lightly Covered Revetments	Cluster Weapons With Fragmentation Or Small Shaped–Charge Bomblets EOGB's Or LGB's With Fragmentation Or LSC Warheads Firebombs		(Direct Hit On Each Aircraft Target)
	General Purpose Bombs Penetrating Weapons Followed By Incendiary Munitions Small Fragmentation Weapons Strafing Attacks With Guns Or Rockets	Instantaneous	(Hit Within Revetment)

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 3 of 7)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
8			
— In Heavily Covered Revetment	Guided Bombs Or Missiles Capable Of Penetrating Roof	Long Delay	(If Sufficient Target Signature)
b. Runways (& Large Roads)	General Purpose Bombs With Steel Nose Plugs	Short Delay Tail Fuze	
c. Hangars	EOGB's or LGB's With Large Warheads	Short Delay	
	General Purpose Bombs	Short Delay	
d. Hardened Aircraft Shelters	Guided Weapons Against Shelter Door Or Track		(If Not Imbedded In Concrete)
	Large General Purpose Bombs	Long Delay	
9. Field Fortifications	General Purpose Bombs	Long Delay	
	Guided Weapons That Impact With Explosive Weights Of 190 Lbs Or Larger (Mk 82 Or Larger)		
10. Supply Depots Or Dumps			
a. Stacked Ammo	CSC And LSC Weapons		Direct Hit
	Fire & Incendiary Weapons		If Wood Crated
	Large Blast & Fragment Weapons		
b. POL Storage Tanks	Large Blast and Fragmentation Weapons		
	Large CSC Or LSC Weapons		(Direct Hit) EOGB's Are Recommended
c. POL Storage Drums	General Purpose Bombs		
	CSC Or LSC Weapons		(Direct Hit)
	Small Fragmenting Bomblets		
d. POL Underground Storage	General Purpose Bombs	Penetration And/Or Cratering (Delay And/Or Steel Nose Plug)	

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 4 of 7)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
11. Land Transportation			
a. Roads	Large General Purpose Bombs	Delay	Dropped Singly
	Smaller General Purpose Bombs	Delay	Salvo Or Stick
b. Trucks	Cluster Weapons With Fragmenting Or Shaped-Charges		
	Firebombs		If Transporting Flammable Or Explosive Cargo
	Fragmentation Or Incendiary Bomblets		
	General Purpose Bombs		
	Guided Weapons		
	Shaped Charge Weapons		
	Strafing Attacks		
c. Railways			
Track	General Purpose Bombs Landmines	(Cratering)	Unretarded
Rolling Stock	General Purpose Bombs	Instantaneous & Short Delay	
	Guided Weapons With Large Warheads		
	Incendiary Weapons		If Cargo Is Reactive Or Car Is Wooded
Locomotives	Cluster Weapons With Shaped-Charges		(If Strikes Vital Components)
	General Purpose Bombs	Instantaneous	
	Guided Weapons With Large Fragmentation LSC or CSC Warheads		
	Projectiles & Rockets		(Given A Hit)
d. Tunnels	H. E. General Purpose	Delay	Unretarded
Bridges			
Permanent	Guided Weapons With Large HE Or LSC Warheads	Instantaneous	
Temporary Timber Deck	HE Weapons		
Cable	General Purpose Bombs With Steel Nose Plug	Delay	
Pontoon	CSC Weapons Weapons That Produce Fragments		
Bamboo	Weapons Delay Fuzed For Underwater Explosions		

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 5 of 7)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
12. Water Transportation			
a. Inland Canals	General Purpose Bombs	Delay	
	Demolition Bombs	Dalay	
	Penatration Bombs		
b. Locks	Air Delivered Torpedoes		
	Floating Mines		
	General Purposa Bombs	Delay & Instantanaous	
	Rockets		
c. Port Facilitias	See 11c, 11e, 12d, e, f, & g, & 13		
d. Merchant Ships	General Purpose Bombs	Delay	
	Guided Missiles With Penetration Capability	Delay	
e. Junks & Sampans	Weapons With 5" or Larger Warheads		(Given A Direct Hit)
	General Purpose Bombs	Delay	
f. Barges & Small Craft	General Purpose Bombs	Short Dalay Or Instantaneous	
	Guns & Rockets		If Cargo Is Reactive
g. Soviet Naval Vessels	Anti-Radiation Missiles		
	Cluster Weapons With Shaped-Charge Warheads		
	E.O. Guided Missiles		
	General Purpose Bombs	V.T. & Delay	Delivered With Accurate Bombing Systems
	LGB's		
	Torpedoes		
13. Buildings	Ganeral Purposa Bombs	Short Delay	
	Guided Weapons With LSC or Large H.E. Warheads		
	Incendiary Weapons		Only if Building Contents Are Combustibla
14. Powerplants	Same As For Building But No Incendiary Weapons		
15. Transformer Substations	Clustei Waapons	Instantaneous	Fragmants Over 30 Grains
	General Purpose Bombs		
	Guided Weapons With LSC And Fragmenting Warheads		
	Rocket & Gun Strafing		

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 6 of 7)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
16. Dams			
a. Earthen	Largest Available General Purpose Bomb	Delay	
b. Concrete	Depth Bombs Large General Purpose Bombs	Hydrostatic Delay	
17. Industrial Targets	General Purpose Bombs	Short Delay Instantaneous	
	Guided Weapons With LSC Or Large H.E. Warheads		If Combustible Contents
	Incendiaries		If Combustible Contents

Figure 10-21. Ordnance Weapon Selection Guide (Sheet 7 of 7)

ORDNANCE TYPE	MINIMUM SAFE DISTANCE (METERS)	
	10% P_I	0.1% P_I
MK 82 LO 500 lb bomb	250	425
MK 82 HD 500 lb bomb retarded	100	375
MK 83 HD 1,000 lb bomb	275	500
MK 83 LO 1,000 lb bomb	275	500
MK 84 LO 2,000 lb bomb	225	500
MK 20 Rockeye	138	280
MK 77 500 lb napalm	0	150
CBU-52	270	450
CBU-58	325	510
CBU-87	185	275
2.75 FFAR	100	175
30 MM	25	180
AGM-65	75	100

P_I = PROBABILITY OF INCAPACITATION OF GROUND FORCES. THE CRITERION FOR DETERMINING CASUALTIES IS THE 5-MINUTE ASSAULT CRITERION FOR A PRONE SOLDIER IN WINTER CLOTHING AND HELMET.

THESE DATA ARE FOR AIRCRAFT DELIVERING WEAPONS PARALLEL TO A LINE OF FRIENDLY TROOPS.

MINIMUM SAFE DISTANCES INCLUDE CEP ACCURACIES OF THE DELIVERY AIRCRAFT. FORTY MILS CEP ARE USED FOR GP BOMBS WITH SIMILAR RELATIVE ACCURACIES ASSUMED FOR THE OTHER ORDNANCE IN THE TABLE.

Figure 10-22. Recommended Maximum Safe Distance From Friendly Troops

some cases, closer delivery can be made if terrain (friendly cover) permits or if the tactical situation is urgent. The TAC(A) and FAC(A) shall inform the ground unit commander of the risks involved prior to commencing such a strike.

10.7.4 Attack Patterns. In addition to understanding attack aircraft system and ordnance capabilities, the TAC(A) and FAC(A) must know the standard ordnance delivery maneuvers and the advantages and limitations of each.

10.7.4.1 Racetrack Attack Pattern. The racetrack pattern (Figure 10-23) offers the best safety margin to friendly forces. It is also the easiest pattern to control since it provides a predictable roll-in point to aid the FAC(A) in acquiring the attack aircraft on each pass and also provides a consistent reference line for corrections on repeated runs. However, the rigidity of the pattern offers little latitude for evasive maneuvering of the attack aircraft. Pattern variations might include a 180° change in run-in heading, and the consequent reversal in pull-off direction, after several runs on the original heading.

10.7.4.2 Wagonwheel Attack Pattern. The wagonwheel pattern (Figure 10-24) provides greater flexibility and safety to the fixed-wing aircraft than does the racetrack pattern, but is much more difficult for the FAC(A) to control. In the wagonwheel pattern, attack is initiated on the target from a circle having the target at its center. The lead aircraft rolls in, calling his heading, and the wingman rolls in 40° to 60° further along the circle, also calling his attack heading. The leader pulls up and joins the cycle to proceed farther along to repeat the same procedure. This ensures that no two successive attacks on the target will be from the same direction and helps to confuse enemy gunners. Because of the unpredictable roll-in direction and faster airspeed of the attack aircraft, the FAC(A) may have difficulty in maintaining positive visual contact at all times.

10.7.4.3 Cloverleaf Attack Pattern. The cloverleaf pattern (Figure 10-25) is a modification of the wagonwheel, with the same general inherent advantages and disadvantages. In the cloverleaf pattern, the leader initiates the attack on the desired run-in, with his wingman in trail behind him. A 270° turn is initiated by the leader on pull-up; the next run-in is initiated 90° from the preceding run, and so on, until the attack is complete. The wingman follows the leader with appropriate separation.

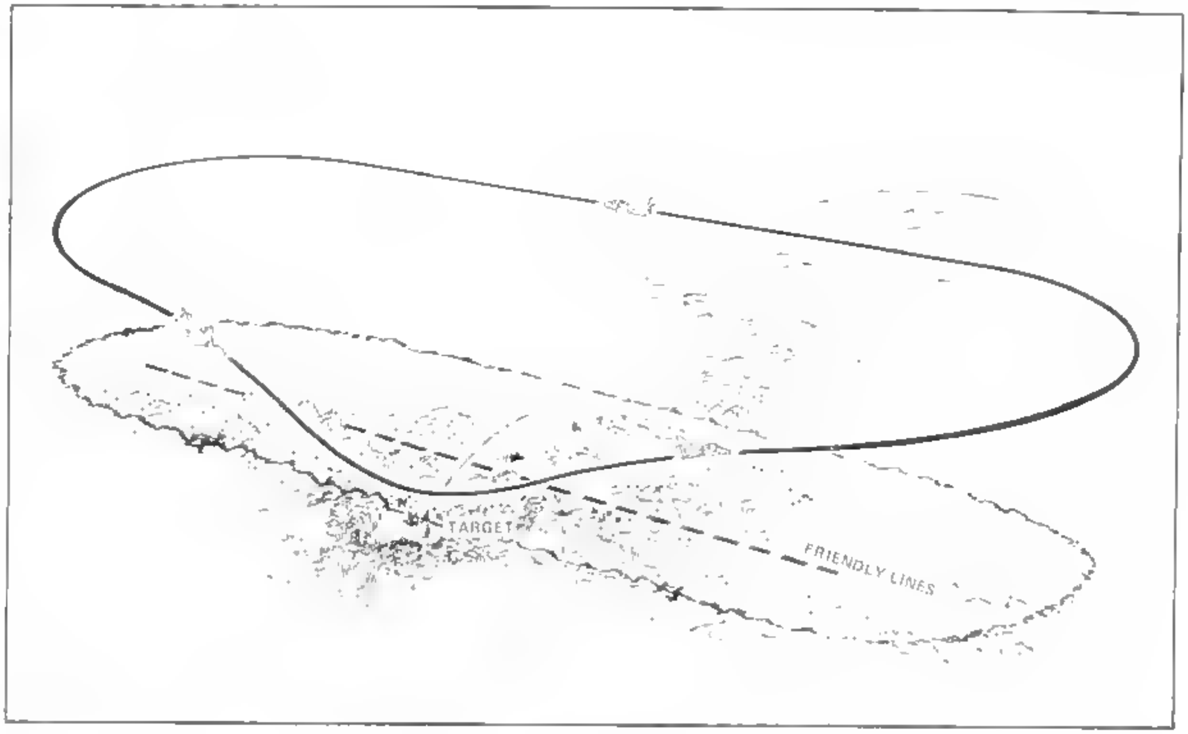


Figure 10-23. Racetrack Attack Pattern

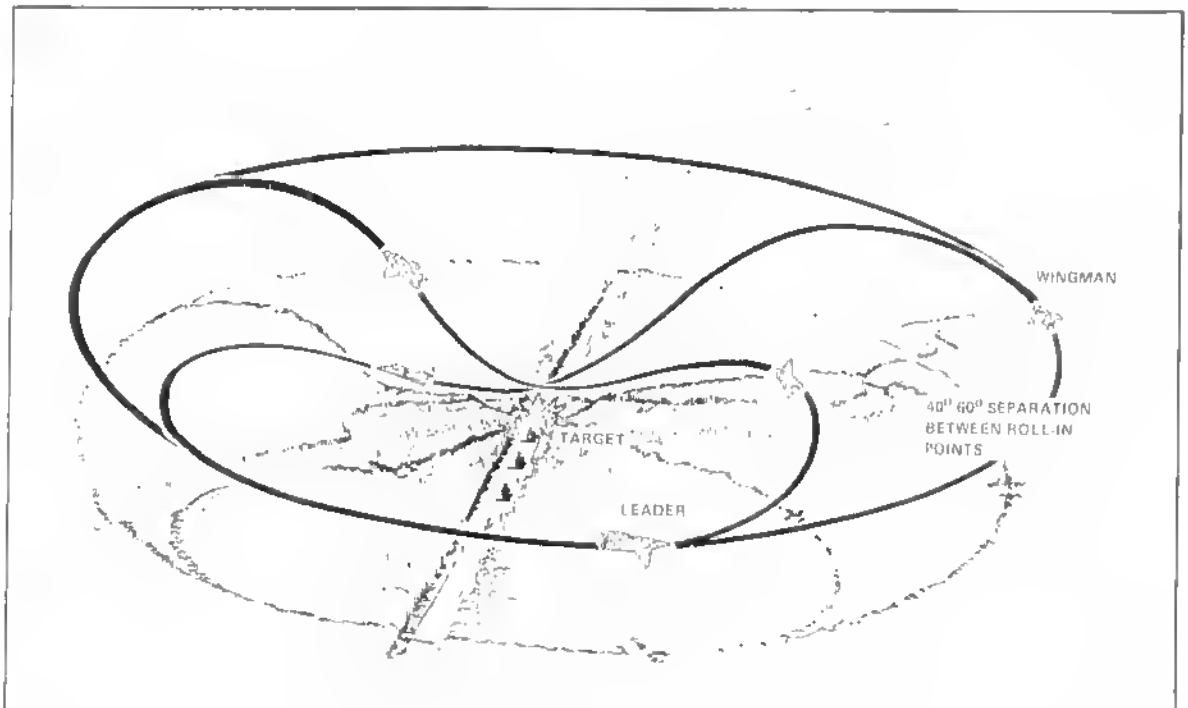


Figure 10-24. Wagonwheel Attack Pattern

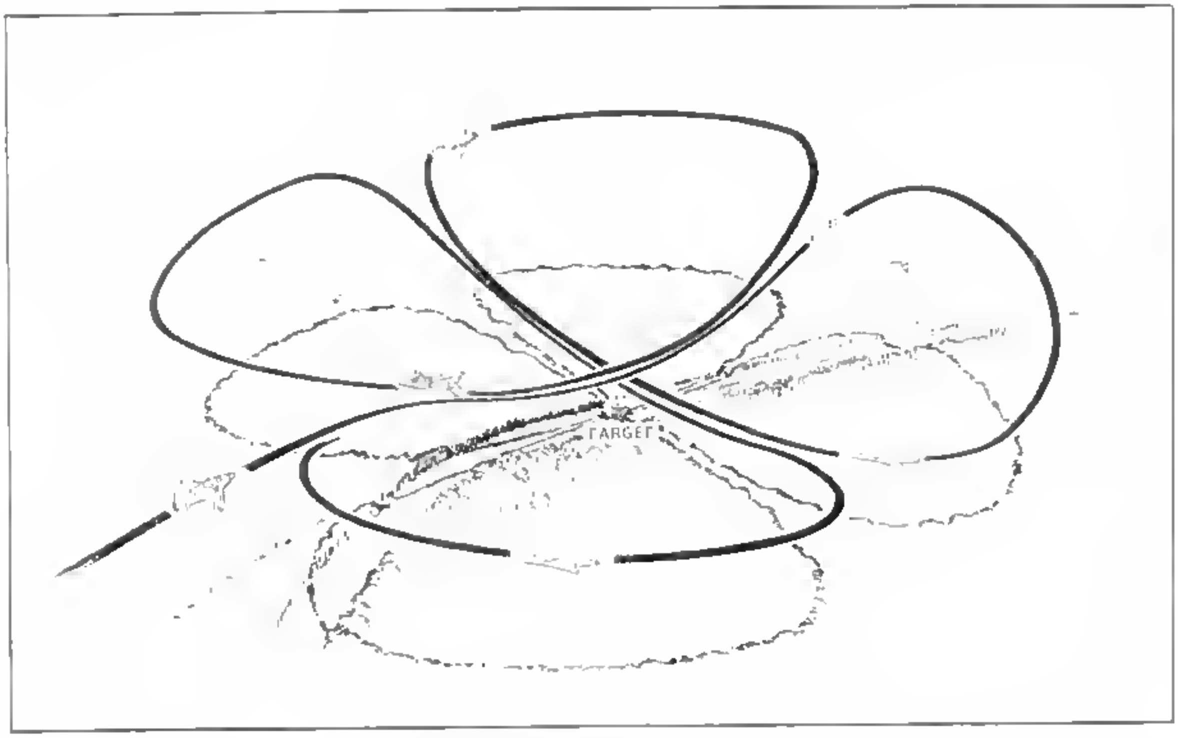


Figure 10-25. Cloverleaf Attack Pattern

10.7.4.4 Pop-Up Attack. The pop-up attack (Figure 10-26) has been devised to permit CAS in some low and high threat areas. The attack aircraft penetrates from an initial point (IP) on a preplanned route to the target, flying at altitudes below the threat envelope. Upon reaching the pull-up point (PUP), the aircraft climbs steeply, acquires the target, and pulls down to a dive delivery. While the pop-up attack provides good accuracy with improved survivability, it requires much more planning than low-threat attack patterns and is less flexible. Acquisition and tracking time is also less, so the attack pilot must be given an accurate target description. If the lead aircraft of a flight is carrying fragmentation ordnance, expect the wingman to establish safe interval for his attack.

10.7.4.5 The Loft Attack. The loft attack (Figure 10-27) is not normally considered a CAS attack pattern due to the relatively large CEPs associated with it. On the high-threat battlefield, however, its use may be considered when improvements in aircraft systems and guided weapons permit greater accuracy. The aircraft penetrates at low altitude on a heading directly toward the target. At a preplanned point, he commences a programmed pull-up, and the ordnance is automatically released in a nose-high attitude. Maximum stand-off is achieved with a release at about 40° nose-high. The limited accuracy of the loft attack is partially offset by the unparalleled levels of surprise and survivability it affords.

10.7.4.6 All-Weather Attack. The four types of all-weather attack currently in use are: air support radar team (ASRT) control, beacon-offset, radar or radar offset, and airborne moving target indicator (AMTI) bombing. The latter three are system drops applicable only to A-6 aircraft (though other aircraft may buddy bomb with an A-6 in the lead). Any jet attack aircraft can drop ordnance under ASRT control. All-weather deliveries provide the TAC(A)/FAC(A) with a valuable option when faced with deteriorating weather conditions. In a high-threat environment, such deliveries would require extensive prior planning and, in most cases, EW support because of the relatively long exposure times of the aircraft to enemy air defense weapons. The TAC(A)/FAC(A) may be called upon to observe and adjust any of these drops when weather conditions are too low for visual CAS. Adjustment of ASRT-controlled bombing is described in paragraph 10.7.5.9, Low/Medium Threat.

10.7.5 Day Airborne Control Techniques

10.7.5.1 Premission Tasks. The five major premission tasks in airborne control involve target location, target analysis, communications, mission clearance, and priority. Location of the target, in coordinates accurate to 100 meters, is the first task. A tacan/DME fix of the target should be accurate to within 1 mile. The controller's position must be located so that intentions are not telegraphed by orbiting directly over the target.

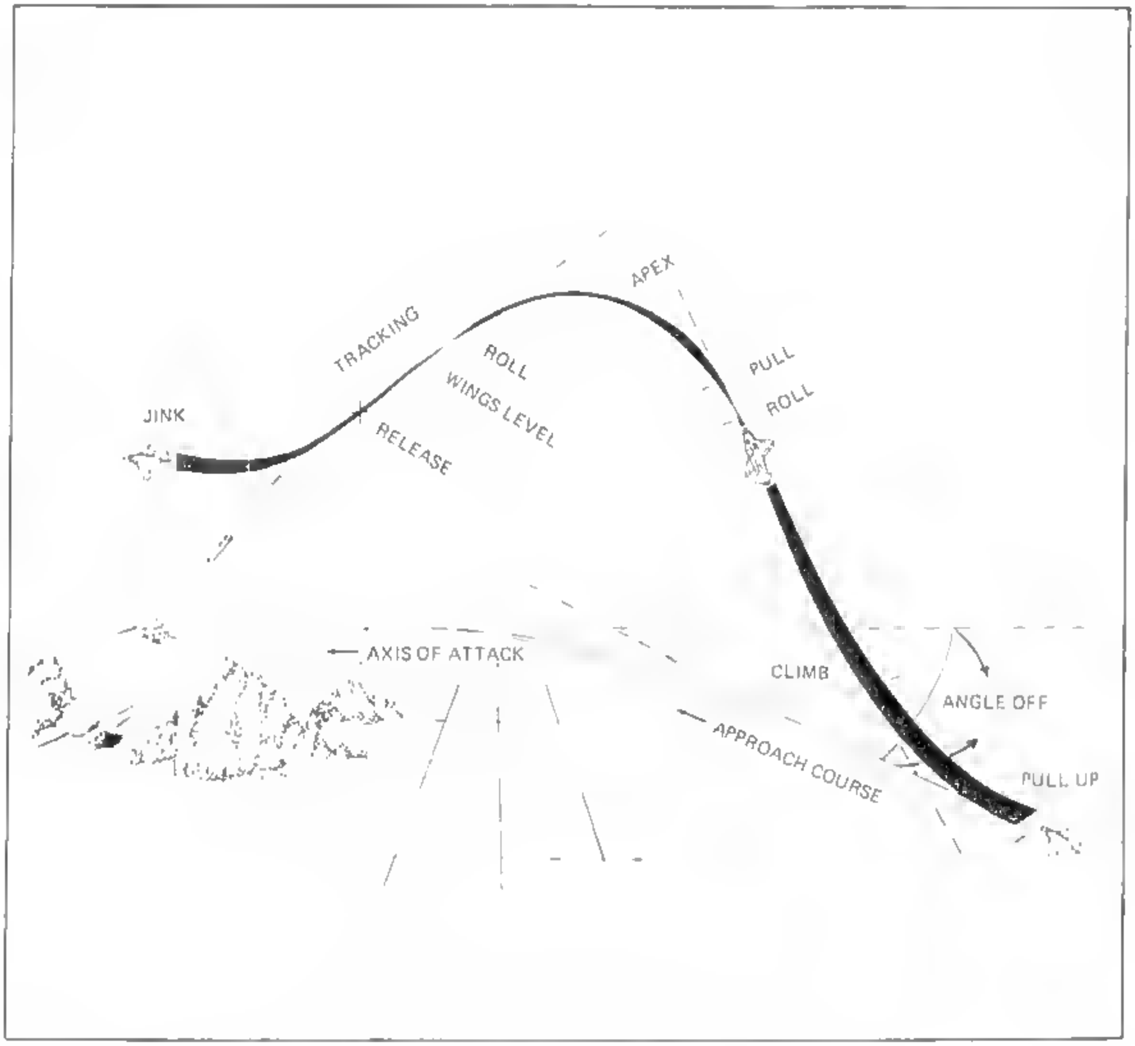
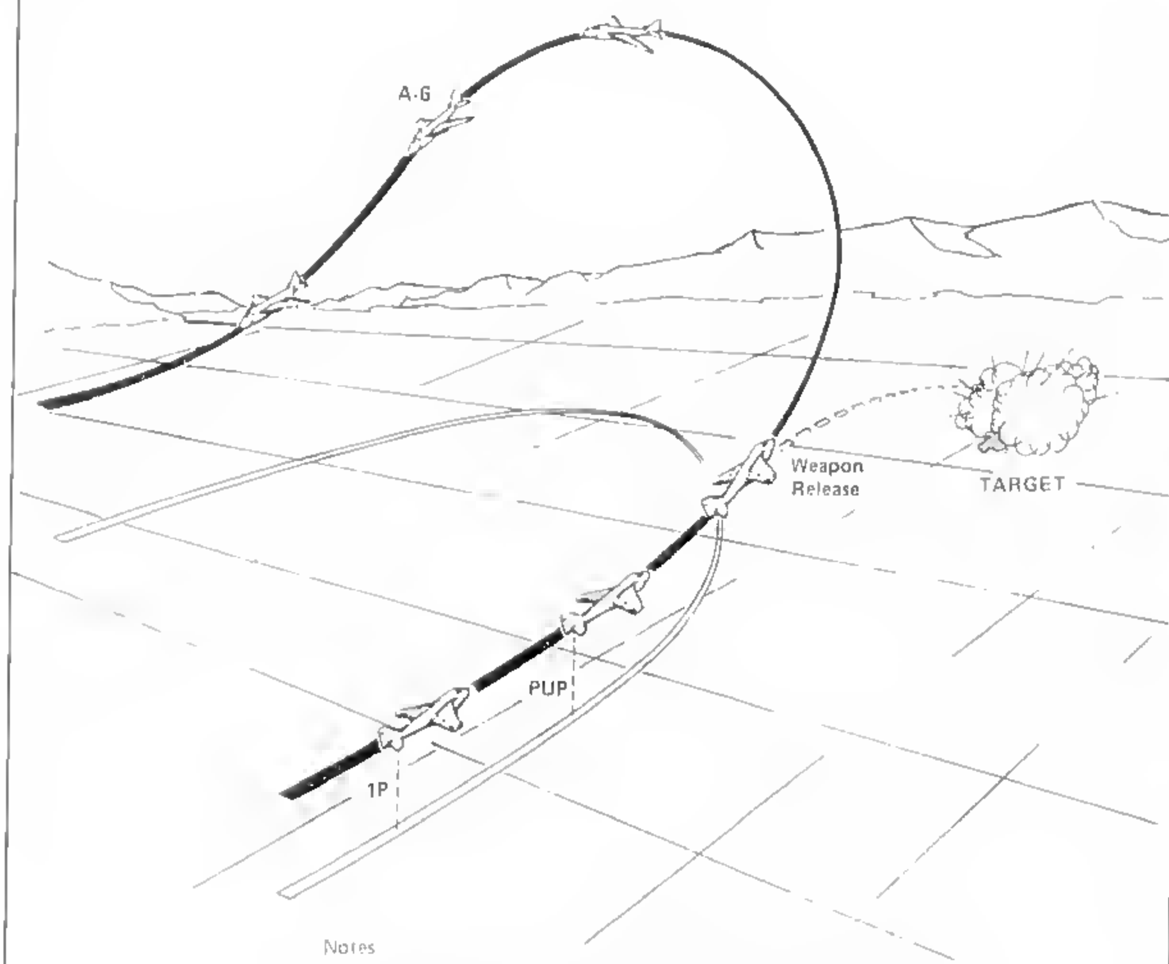


Figure 10-26. Typical Angle-Off Pop-up Attack



Notes
1. The TAC(A)/FAC(A) should provide course and distance in nm from IP to target.
2. The attack pilot computes the time in seconds from IP to Pull-up.
3. The TAC(A)/FAC(A) should clear the strike immediately, if possible.

Figure 10-27. Typical Loft Attack From a Visual IP

Location of rendezvous with attack aircraft requires tacan/DME radial and distance or a prominent terrain feature. Visually spot all friendly unit locations within 1,000 meters of target. For the target analysis task, the type of target and its protection must be determined, including size, hardness, natural/manmade protections, and tactical influence. Weapon selection will involve the type and amount of ordnance required to achieve desired damage to target, plus fuzing considerations. Communications must be established with control agencies (DASC, TAOC or ASRT, and TACC), ground unit involved, and other aircraft influenced by the air strike such as helicopters. Clearance to conduct the mission must originate with the local ground unit commander who will be affected by the air strike, or with the unit commander having authority over the area. Coordination with other supporting arms and associated units, such as reconnaissance teams or allied forces, must be assured. Mission priority should be assigned by the ground unit commander needing the support. If no ground unit is involved, the TAC(A)/FAC(A) assigns the priority, and DASC will verify or reassign priorities as necessary.

10.7.5.2 Requesting Aircraft. Figure 10-28 illustrates the typical procedures used to obtain close air support. The primary source for aircraft is DASC. Either the tactical air request net or tactical air direction net can be utilized, but check with the ground unit since they may have previously requested air support. Three sources of air support are on-station aircraft, alert aircraft, and divert aircraft. On-station and on-call aircraft are prebriefed for specific missions, and on-station orbiting aircraft are awaiting mission assignment from DASC. Alert or hot-pad aircraft are available for emergency missions or priority missions. These aircraft must be scrambled by the TACC or TADC. Divert aircraft may be obtained for your control from missions of lesser priority, other TAC(A)s/FAC(A)s, or because of inclement weather in their primary target area. Information which must be provided to the DASC when requesting strike air support includes the following:

1. Controller's call sign and location

2. Type of target and priority of mission

3. Supported ground unit identification

4. Location of target

5. Type and amount of ordnance desired, and fuzing

6. Current weather in the target area.

The DASC will provide the following information to the controller:

1. Aircraft call signs and line-up for the mission

2. ETA and ordnance load for first air support flight

3. Assigned TAD frequency for conduct of mission

4. Clearance to run the mission

10.7.5.3 Attack Planning. Attack planning includes determining the target elevation, the best approach to the target, attack heading, pull-off direction, attack pattern (if multiple runs are feasible), and retirement route.

An accurate value for target elevation is important. To convert elevation data from meters to feet, multiply the elevation in meters by 3.28. For snakeye bombs or napalm, take target vegetation and trees into consideration. Conditions permitting, plan the pull-off:

1. Away from hazardous terrain or enemy ground fire

2. Around the friendly unit

3. Away from bad weather

4. Toward the nearest safe area.

In a low-threat environment, multiple runs may be possible. If so, decide what attack pattern will produce best results and what ordnance will be delivered on each pass.

Note

> If the ordnance load includes napalm, consideration should be given to dropping it first. This will allow higher attack airspeeds on subsequent passes and reduce the danger or enemy ground fire igniting the napalm on the aircraft. A disadvantage to this plan is the chance of subsequent bomb blasts smothering the napalm.

10.7.5.4 Coordination. The major coordination requirements for airborne controllers are keeping other agencies informed of the situation and the assignment of orbit points to other aircraft when needed. The ground unit needs to know how long it will be until strike aircraft arrive, and which ordnance will be delivered at what position. Other aircraft in the area, such as transport helicopters and gunships, require coordination regarding suppressive fire, timing, and patterns. Control agencies which must be kept

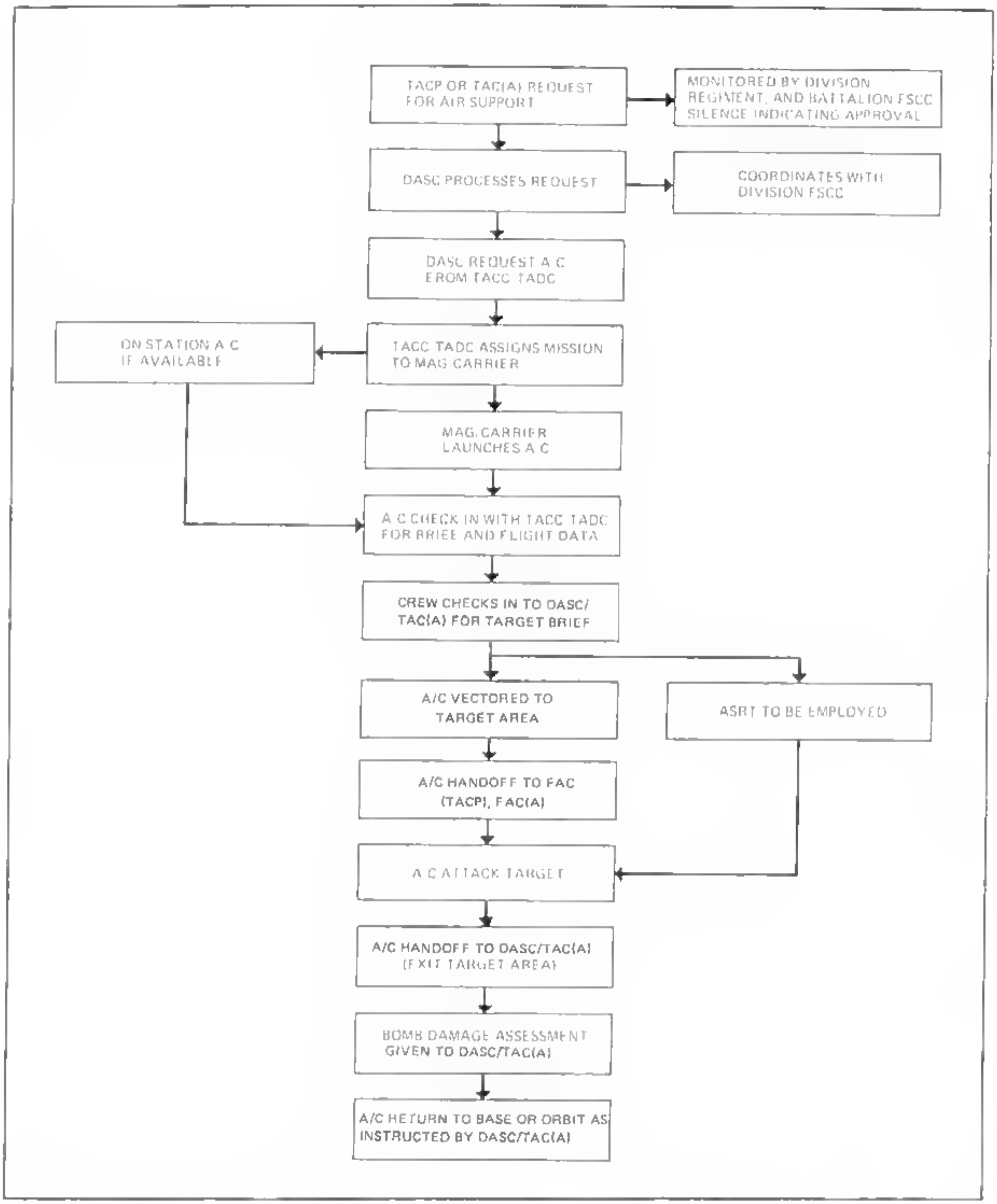


Figure 10-28. Close Air Support Mission Flow Chart

informed are the direct air support center and fire support coordination center. In addition, other supporting arms may require coordination if it will be necessary to check fire artillery or naval gunfire. The need for establishment of restrictive fire plans and for artillery or naval gunfire should be determined in case they are needed to supplement the air strike. Coordination with other aircraft in the assignment of orbit points may be needed. Helicopters must remain clear at an orbit point which is safe from the enemy antiair threat. In low-threat areas, follow-on flights of fixed-wing aircraft should orbit overhead at higher altitudes to observe, while avoiding interference. Position of the orbit point should be identified by tacan radial and DME distance, or by large prominent terrain features. If necessary, 1,000-foot separation altitude assignments should be made for multiple flights. To avoid interference with other supporting arms, orbit points should be established clear of gun-target lines and above the maximum ordinate associated with either artillery or naval gunfire.

10.7.5.5 Rendezvous With Strike Aircraft. Initial communications with strike aircraft will be on the TAD net, in accordance with DASC instructions. As quickly as possible, the FAC(A) should obtain the following information from the strike aircraft: number of aircraft, type and call sign, number and type of ordnance carried, target area ETA, and fuel time on station (minutes). The following information must be passed to the strike aircraft by the FAC(A): FAC(A) position (tacan radial/DME), FAC(A) aircraft type and altitude, artillery/naval gunfire information, and traffic advisories on other aircraft in the area. At the FAC(A)'s discretion, the briefing can be initiated as soon as the flight checks in, unless there are problems in marrying up with the fixed-wing aircraft.

The preferred method for rendezvous is the use of tacan radial and DME positions. Other methods include UHF homing with tacan air-to-air ranging, description of large or prominent terrain features, rendezvous over a point known to both FAC(A) and strike aircraft before proceeding to target, and use of TAOC or ASRT radar. On CAS missions, either a ground FAC or a FAC(A) must establish visual contact with the attack aircraft and clear the strike before ordnance is delivered. Other information required from the FAC(A) by strike aircraft includes orbit points (if necessary), general situation brief, expected delay on attacking the target, and weather in the target area.

10.7.5.6 Target Briefing. The briefing for strike aircraft should always proceed from general information to specific data. Whenever possible, a brief situation report should be included. See Figure 10-29 for the standard low-threat CAS briefing format. The tunnel method of briefing should also be used for terrain description, proceeding from general to more specific features of target designation.

The CAS brief employed in medium and high threat environments is the same as in a permissive threat environment. This brief is given in a standardized format. This permits the information to be passed quickly and minimizes the effectiveness of enemy communications jamming. Figure 10-29 gives the standard briefing format. An explanation of each item follows.

MSN# — Mission number. The mission number is assigned to a flight by the DASC. The mission number will be used as the flight's call sign. It can be coded for use in command and control.

ORD — Ordnance code. The ordnance code denotes what weapons and fuzing are to be carried.

ROUTE — The route is the routing assigned to the flight for the entire mission. It is given in operational code words.

EN ROUTE FREQ — The frequencies used by the strike aircraft during the conduct of the mission. They may be associated with color codes.

MISSION CODES — The various codes associated with the conduct of the mission. This will normally include the code words, if assigned, for CONTINUE, CHANGE, CANCEL, OR ABORT.

CONTACT POINT (CP) — The contact point to which the strike aircraft has been directed to proceed, and where he will normally make contact with the terminal controller.

CONTROLLER CALL SIGN — The call sign of the terminal controller that the strike aircraft is to report to.

FREQ — The frequency on which the strike aircraft will contact the terminal controller.

1. I.P. — initial point.

2. HDG — the heading from the I.P. to the target, given in degrees magnetic.

Note

The "LEFT" or "RIGHT" offset is an optional segment of the CAS brief. However, when transmitted (after heading) it becomes a mandatory direction of offset

CAS TARGET BRIEFING FORM

1. General. The CAS pilot brief is a message card designed to give the pilot all the information needed to conduct a CAS mission.

Msn # ______________________ Ord ______________________

Route ______________________

En Route freq ______________________

Msn Codes: Continue __________ Change __________

Cancel __________ Abort __________

Contact Point:

CP ____ __________ /Controller Call Sign __________ /Freq __________

____

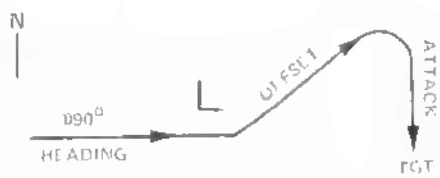
1. IP ______________________
2. Hdng __________ °Mag __________ Offset: L __________ R __________
3. Distance ______________________
4. Tgt Elev ______________________
5. Tgt Desc ______________________
6. Tgt Location ______________________
7. Mark Type __________ Code __________
8. Friendlies ______________________
9. Egress ______________________
10. BCN-Tgt __________ BRNG/BCN Grid __________
11. BCN-Tgt __________ Meters/Tgt Grid __________
12. BCN Elevation __________ Feet __________

Remarks:

TOT/TTT ______________________ (min) "HACK"

Figure 10-29. CAS Target Briefing Form

deemed so for the protection of friendly troops on the ground, or to facilitate supporting arms adjustment, safety of flight, etc. The offset restricts the ATK A/C to the left/right of the ATK heading.



3. DIST — the distance from the I.P. to the target, given in nautical miles to the nearest tenth.

4. TGT ELEV — the target elevations in feet mean sea level (MSL).

5. TGT DESC — a brief and general target description to help the pilot anticipate visual cues for target acquisition.

6. TGT GRID — the six-digit alphanumeric UTM GRID, e.g., AW6023510.

7. MARK — the type of mark will be given (smoke, laser, etc.) and any codes required by that type of mark.

8. FRIENDLIES — the friendly position will be given in cardinal headings from the target with distance in meters.

9. EGRESS INSTRUCTIONS — use the cardinal direction for egress and the name of the egress control point.

10. BEACON TO TARGET BEARING (IN DEGREES MAG.)/BEACON GRID COORDINATES — location of the beacon.

11. BEACON TO TARGET RANGE (METERS)/TARGET GRID COORDINATES.

12. BEACON ELEVATION (in feet MSL).

Note

Lines 10 to 12 are used with the RABFAC BEACON.

Remarks:

FINAL ATTACK HEADING —

HAZARDS — friendly fires, terrain features, final attack heading, expected threat, not a mandatory item.

WEATHER — target winds and altimeter setting. Not a mandatory item.

THREAT —

ORDNANCE DELIVERY —

AIRSPACE COORDINATION AREAS —

TIME ON TARGET/TIME TO TARGET — Time On Target refers to a specific time, e.g., 1452, that the ordnance from the strike aircraft is to impact the target. This term is normally associated with a pre-planned scheduled mission. Time To Target refers to a specific number of minutes and seconds to ordnance on target, e.g. "6+00. . . HACK."

TIMING METHODS — a common reference time is essential to accomplish the high degree of coordination necessary to integrate fire (including CAS) with maneuver. At the present time there are two methods that are in common usage. The first is called the "Running Clock." Essentially, the senior FSCC maintains a master clock that may be started at a time designated as "zero," and all events are referenced to it as the minutes and hours elapse over the course of an operation. This system is somewhat unwieldy because of the requirements to conduct numerous time checks between all elements of MAGTF to ensure synchronization. The preferred method at this point is to use a "Universal Time." In this method, all clocks are referenced to "Coordinated Universal Time" as given by the U.S. Naval Observatory. This may be done by individual units VIA telephone (AV 294-1800) or HF radio (5.000, 10.000, or 15.000). This Zulu time is then normally converted to the local time zone in which the operation is taking place. The advantage is that it eliminates most of the time checks between units. In any event, the MAGTF command element should clearly establish the timing method and procedures to be utilized in the operation order. It should also be kept in mind that the terminal controllers still have the option of using a Time To Target (TTT) to control CAS/CIFS.

10.7.5.7 Methods of Target Marking. The normal method of target marking is utilization of 2.75-inch FFAR white phosphorous rockets. As an alternate method, 2.75-inch FFAR high explosive rockets can be used to mark the target; however, the smoke dissipates rapidly. Some type of ground reference should be available for strike aircraft visual relationship to use in bombing. Do not mark the target until you have acknowledgment that the strike aircraft are in position to observe.

Other marking methods include the use of smoke grenades, and white phosphorous (mortar/artillery/naval gunfire) shells.

CAUTION

Exercise care in the use of hand-held smoke. Do not call for a specific color, since the enemy could have the same smoke capability.

Mortar, artillery, or naval gunfire white phosphorous may be the safest to use in highly defended target areas, but detailed advance coordination with the units involved is required. If the ground units can see the target and can reach it, a more accurate mark is provided by mortars (using a WP round if available). Overflight of the target is the least desirable method because it is inaccurate, and is hazardous to the FAC(A).

10.7.5.8 Calls and Clearances. Calls required by strike aircraft during the attack are rolling in and off target. If the FAC(A) encounters difficulty in acquiring the strike aircraft, he should request a call of abeam or 180° position, in addition to the rolling-in call. Standard terminology in accordance with Operational Brevity Codes (ACP 165) should be used by the FAC(A) in communicating with attack aircraft.

Additional terms of primary importance include the following:

TERM	MEANING
CONTINUE	You appear to be tracking on the correct target and are cleared to continue the run.

CAUTION

CONTINUE" is not a clearance to release ordnance.

CLEARED HOT	You are cleared to release the requested ordnance at your discretion.
ABORT ABORT, ABORT	Abort run immediately; do not release ordnance. Return ordnance switches to SAFE. The NATO term for abort is STOP, STOP, STOP.
GO HIGH AND DRY	Establish an orbit pattern with ordnance switches SAFE and await further clearance. The NATO term meaning orbit is HOLD HIGH/LOW.

The FAC(A) may call "TALLY HO" and "CONTINUE" to each strike aircraft as it is acquired during roll-in. At any time during an ordnance pass by the strike aircraft, if the FAC(A) has doubts for any reason as to the safety of the pass, or the pass, or the effectiveness of the drop, he should require the strike aircraft to abort the run and/or go high and dry while the situation is clarified.

10.7.5.9 Low/Medium Threat. Considerations for strike aircraft patterns involve ordnance release conditions and weapon range dispersion. Nonretarded ordnance is normally released in a 30° dive with a release altitude of 3,000 feet AGL. This results in a roll-in altitude of approximately 7,000 to 10,000 feet AGL. Retarded ordnance and strafing usually require dive angles of 5° to 15°, with release altitude varying from 500 to 1,500 feet AGL. This normally results in a roll-in altitude of 2,500 to 4,000 feet AGL, or less. Since range dispersion for air-delivered weapons is greater than deflection error, safety of friendly forces requires that the run-in heading parallel the front lines as closely as possible.

There is no requirement that the FAC(A) must be in a certain position during the strike or must fly a certain pattern. The primary considerations for controller's position are as follows:

1. Maintain a position for observation of the target, the supported ground unit, and the strike aircraft at the time he is in drop position to assure maximum safety of friendly personnel when clearance is given.

2. Attempt to keep in position to roll-in for an ordnance pass when necessary, either for remarking the target or for suppressive fire.

3. Hold a position which will not interfere with the strike aircraft.

Patterns which can be flown for optimum FAC(A) position include the inside racetrack, outside orbit, and figure eight. The inside racetrack is maintained over the friendly unit, but inside the attack aircraft, and provides the best protection for the friendly unit. The outside orbit may provide better observation of the target; however, greater exposure to ground fire is also possible. The figure eight pattern can be flown inside, outside, or crossing between the two options. This provides continuous observation of target, friendly unit, and strike aircraft, and keeps the FAC(A) in position for target remark of fire suppression. Altitude should be maintained out of range of small arms fire (1,500 feet), and airspeed should be as high as possible, consistent with good observation requirements, and within aircraft performance capability. Be aware of (and avoid) frag patterns from strike ordnance.

Although any method which involves a direction and a distance from a ground reference may be used to adjust ordnance impacts, the preferred method for FAC(A) corrections is the use of a clock code and distance in meters from the last weapon's impact. When giving corrections, consider the normal CEP of the particular weapon and its area of effectiveness. It may not be necessary to achieve a direct hit on a target to destroy or neutralize it. Other considerations for adjusting impacts are target neutralization versus destruction, area coverage versus point destruction, and immediate suppressive fire for helicopter support versus target destruction with delayed results.

When weather precludes the precision bombing patterns of close air support, ASRT controlled bombing runs can be adjusted to destroy enemy positions. Unless surprise is necessary, it is best to have one bomb dropped as a spotter round and make adjustments from the impact. Adjustments are made using the standard clock code, with the target in the center and the run-in line being the 12- and 6-o'clock line. Bomb impact is passed to the ground radar controller in bearing and distance from the target (example: "IMPACT 4 O'CLOCK, 75 METERS FROM THE TARGET"). Corrections and communication are often difficult, since most messages must be relayed through the attacking aircraft due to terrain masking. The attack aircraft can relay direct range from pickle point, experience has demonstrated that 10,000 5,000, and 2,000 meters are the most meaningful to the OV-10 crew. Having previously examined the eight-place grid on the ground and being aware of the attack heading, the OV-10 should be positioned at least 5,000 meters away from the target until it is determined that the TPQ gear is calibrated accurately. Utilizing the 10,000- and 5,000-meter position reports, be prepared to proceed to the target area when the 2,000-meter report is given. Flying at 150 to 160 knots from 5,000 meters out, the OV-10 will be 2,000 meters from ground zero at impact. Upon observing the impact, proceed to the area and give corrections. By utilizing intervalometer settings, the attack aircraft can saturate area targets and virtually overlap bomb craters to ensure point target destruction. The OV-10 crew needs only to tell the attack pilot how many bombs are desired in a given stick and how long a stick is desired. The correction should be for the center of the target, followed by explanation of the stick length desired along the attack heading in relation to the target center.

10.7.5.10 Special Considerations. Changing weather may dictate changes in ordnance requirements and delivery tactics. Do not depend on holes in the overcast. When controlling other aircraft, assign holding points, or orbit areas which prevent their interference with the conduct of the strike, but keep them immediately abreast of the situation. The TAD frequency used by the FAC(A) is a discrete frequency; all nonessential communications should be accomplished on either FM or another UHF. If the air strike is to be utilized as suppressive fire for the transport helicopters, thorough coordination with them is required. When the FAC(A) has a wingman assigned, confusion as to which is the FAC(A) can be eliminated by holding the wingman out of the area, or by verifying the lead aircraft (landing light on, wing rocking, identification turn). For extremely close drops (inside 200 meters) mark the first drop farther away from the friendly unit, moving gradually into the target. Assure that all parties involved understand how critical and tight the situation is. The friendly units must mark their positions very well and must protect themselves as much as possible. The controller should have positive, two-way UHF communications with the strike aircraft and positive, two-way communications with the supported infantry unit. However, receiver-only attack aircraft may be used as the situation dictates.

10.7.5.11 High Threat. In order to be successful in this environment, Marine aviation and Marine air command control agencies must be capable of operating at

peak efficiency and with maximum flexibility. Mission preplanning becomes more and more important for effective CAS. Command, control, and communications on egress are further complicated by friendly air defense identification requirements.

Coordination points between the takeoff point and target are required and should be standardized throughout the combat theater. Modification on at least a daily basis and secure voice will provide some degree of communications security to preclude compromise of specific missions.

1. Tactical departure (TD) — departure procedures and control will be determined by remoteness from the threat and threat's sophistications. In all cases, emissions control should be paramount and, whenever possible, noncommunications departures will be accomplished. Specific procedures for various weather and tactical situations will be promulgated by the aviation or departure facility commander.

2. Ingress rendezvous point (IRP) — after TD, various takeoff intervals, weather situations, and other variables will require that a well-defined geographic point be prebriefed and utilized for attack aircraft rendezvous. This is the last assured air-to-ground communication point. Weather conditions may dictate that it be relatively close to the departure airfield and may be used as a coordination point for airfield defense identification and for required control adjustment by the DASC.

3. Ingress control point (ICP) — an intermediate coordination point(s) for supporting aircraft rendezvous and initial contact with terminal or intermediate controllers. It should be a well-defined geographic coordination point just outside the enemy ADA threat. The ICP will be utilized also for initial beacon acquisition on RABFAC missions. It allows for confirmation of attack force commitment to a preplanned mission with necessary amplification and adjustment, or for diversion to a more urgent mission.

4. Initial point (IP) — well-defined geographic initial points normally within enemy ADA threat areas will be located throughout the theater of operations. They must be distinctive and vertically defined to allow precise navigation update capability for low-level aircraft. These initial points will be utilized by the terminal controllers and aircrews to accurately position the aircraft for ordnance delivery on target.

5. Egress control point (ECP) — a well-defined geographical control point just outside the enemy ADA threat where contact with terminal controllers normally terminates. The DASC is the overall coordinator for this point which may be controlled by a TAC(A), FAC(A), or FAC.

6. Egress rendezvous point (ERP) — attacks often prohibit expeditious aircraft rendezvous off target. The egress rendezvous point is used principally to effect that rendezvous. It needs to be well-defined geographically and should be beyond effective enemy ADA ranges. The EFP may also be used to organize for reattacks or subsequent missions.

7. Penetration point (PP) — a well-defined geographic coordination point utilized for reentry into the friendly air defense network. It should be located beyond the intercept zone of the friendly SAM systems confronted, with operable IFF equipment and/or tactical recoveries from these points. Aircraft without IFF or communications capability will commence identification procedures designated by the aviation commander, prior to or at the PP. Lost comm/IFF-out aircraft may also loiter at this point for possible rendezvous with friendly aircraft for secure recovery.

8. Tactical recovery (TR) — tactical recovery procedures and control will be promulgated by aviation commander and dictated by threat, friendly defensive posture, and weather. Strict EMCON frequent diversions, and threat dictated low-altitude recoveries will necessitate theaterwide standardization. This will ensure detection and identification by control agency radars (TAOC) in addition to friendly front line SAM radars.

In a high threat, utilize supporting arms to mark the target if possible; if not, plan a pop-up mark or a lofted mark time to impact a few seconds prior to the attack aircraft's pull-up. A ground FAC, if available, should provide the correction from the mark. Should a ground FAC not be available, the FAC(A), after egress and computed time for smoke plume is effected, may pop for a visual of the target area. A correction can then be passed to the CAS aircraft utilizing a cardinal direction from the smoke as in the following: 200 METERS SOUTHWEST

10.7.5.12 Section FAC(A) Tactics and Procedures. As the threat increases, we need to evaluate the requirement for mutual support and section integrity over assets allocation in the AOA. Traditionally, our mission has generally been one of single ship operations because of reduced threat and requirement to allocate assets to the ground commander around the clock. If we decide to utilize two aircraft to conduct FAC(A) missions, employ the section as follows:

1. Option One — crew duties are divided between the lead and wing aircraft. One aircraft is primarily tasked with ingress, mark, and control. The wingman holds just outside the target area and is primarily responsible to control SEAD, integrate the strikers with the ground, and be the primary communication link between ground units, DASC, and strikers. His holding position allows him relative protection from the threat systems but he can provide cueing to the marking aircraft for bogeys and SAM/AAA launches on egress.

2. Option Two — the section ingresses to the target in combat spread with one aircraft designated to provide the mark. The wingman positions himself for mutual support and has his nose pointed into the target area to provide immediate suppressive fires to cover the leads mark and egress. Both aircraft then tactically egress the area. Lead calls the correction from the mark. Control and cleared hot is provided by the first aircrew who sees the strikers regardless of whether it is lead or wing aircraft. This method of fighting your way in and out would provide maximum mutual support, but both aircraft risk exposure to threat systems.

3. Option Three — one aircraft positions himself to loft a mark while the other aircraft moves forward to provide a correction from the mark and terminal control. After the mark is lofted, the second aircraft moves to rejoin the primary terminal control aircraft to regain mutual support and lockout doctrine for the section.

These are only a couple of possible options and variations. All three can be adopted and utilized. The squadron and ACE planners will have to decide how to commit the limited Bronco assets to employ these tactics. The Big Tradeoff is because of the force structure of FAC(A) aircraft to support the MEB when weighed against the amount of FAC(A) coverage the GCE wants.

Final Bullets to Remember:

- Egress Aggressively.
- The ground has a P_k of 1.0; SAMs/AAA/MIGs are less.
- In your final run, you're on government time.

10.7.5.13 Communication Techniques. Close air support, particularly immediate close air support, is highly dependent upon radio communications. As mentioned earlier, radio communications are highly vulnerable to enemy interference. The two most frequently employed and disruptive enemy tactics are communications jamming and imitative deception. A number of techniques may be employed to counter the effects of these methods and permit continued close air support. The techniques include the following:

1. Masking — masking is based on the fact that both radio communications and interference require line of sight between transceivers. With this in mind, control agencies establish control points that are masked from enemy interference by distance (Earth curvature) or vertical terrain features. This stand-off posture enables controllers to pass mission briefings for immediate target.

2. Burnthrough — communications jamming does not always negate friendly communication; it merely degrades communications to varying degrees. The closer the distance between attack aircraft and controller, and the greater the distance between them and the jammer, the less effective the jammer is.

3. Brevity — transmit only essential information on the radio using prebriefed operation codes and burst transmissions. Operations codes facilitate and abbreviate the transmittal of mission information. These codes should exist in current planning documents, and in daily operational FRAG orders. Operational codes may include coordination points, significant geographic locations, and tactical control measures.

4. Chattermark — a prebriefed frequency rotation plan is essential for CAS chattermark procedures. During the various phases of a mission (i.e., departure, en route to REP, CP, IP, target and egress), the attack aircraft will monitor the appropriate prebriefed frequency. During an exchange of information, if excessive jamming is encountered, the attack aircraft and terminal controller will move to prebriefed alternate frequencies. Authentication procedures will be essential to preclude effective communications intrusion and should be coded.

No one tactical/countermeasure to communication jamming will be completely effective by itself. The tactical environment, communications equipment, and task to be accomplished will dictate those counters that are necessary.

10.7.5.14 Bomb Damage Assessment. Bomb damage assessment is needed by several agencies such as the strike aircraft, DASC, the friendly unit supported, and the FAC(A) for his after mission report. Weapon CEP and weapon effect on a particular target should be considered when giving a BDA. Information which must be included in the BDA is as follows:

1. Target/mission number

2. Percentage of ordnance delivered on target

3. Percentage of effectiveness or ordnance delivered

4. Target coordinates

5. Actual damage, including secondary explosions, secondary fires, confirmed or probable enemy killed, number and type of structures or vehicles either destroyed or damaged

6. Unit and/or operation supported

The BDA is obtained by direct observation of the target by the FAC(A), or by reports from friendly units in the target area.

WARNING

During target overflights, beware of ground fire and blast/fragmentation from secondary explosions. Include any dud ordnance in the BDA to strike aircraft; the actual location of duds should be passed to the infantry and to the transport helicopter flight leader.

Note

BDA, though important, may not be possible to attain by the OV-10 in certain high threat situations; and in these situations, attempts should be made to obtain BDA from other sources.

10.7.6 Night CAS Control. Night CAS imposes even greater responsibilities on the FAC(A) than day CAS. Target marking and aircraft acquisition are more difficult. Normally, illumination of the target and hazardous terrain must be provided. Even in clear weather with illumination, pilots must deal with the problems of vertigo, target fixation, inadequate terrain discrimination, and increased potential for midair collision. Accomplish as much planning and coordination as possible prior to the arrival of the attack aircraft on-station. Friendly units should be prepared to mark their positions and, if possible, the target. If illumination is required, adjust it well in advance. Clearance to conduct the mission can be a significant problem if the target is close to friendlies. A good understanding of the desires of the ground unit commander, proper preparation, and professional voice procedures will help ensure there is no delay in obtaining clearance.

Use radio navigational aids, radar vectors, and aircraft lighting to rendezvous with other mission aircraft. The target briefing should cover thoroughly the method of marking the target and friendlies, location of hazardous terrain, and other aircraft in the area. If possible, establish positive aircraft separation by altitude or by airspace assignments. This will permit lights-out operation to the maximum extent possible when required by the threat.

Commence illumination a few minutes prior to the strike to permit any final adjustments. Flares are normally positioned up to the 12o'clock position on the target run-in line, and at the 6-o'clock position at 500 to 1,000 meters, unless the strike aircraft desire other positions. Flares should not drift across the run-in line above the minimum pullout altitude of the attack aircraft. After initiating illumination, it should be maintained at a constant level until the mission is completed. Initial flares should be used to determine wind within the target area.

10.7.6.1 Low Threat Tactics. In a low threat environment, aircraft paraflares provide the best illumination. Although several types of aircraft can be used as flareships, normally a cargo-type (C-130) aircraft with a long endurance capability and large flare capacity will be used. Normal time on-station for the cargo-type flareship is from 3 to 5 hours, including illumination time. Normal illumination consists of strings of 4, 6, or 10 flares. Maximum illumination would be strings of 10 to 12 flares. The flare aircraft usually operates between 4,000 and 8,000 feet AGL. After establishing the pattern, the flare aircraft will maintain a tacan holding pattern. The flare pattern is a racetrack type, offset to account for wind correction, with one leg of the pattern parallel to the run-in line. The pull-off direction is opposite to that of the strike aircraft.

Strike aircraft may be employed, either with one aircraft in the flight of two acting as the flareship, or with a split ordnance/flare load on each aircraft. An OV-10 with flare capability can also serve as the flareship.

WARNING

Unlit or burned out suspended flares are a hazard to flight.

Target designation considerations at night are generally the same as during daylight, except that more frequent remarking of the target is necessary.

Unless otherwise desired or specified, the same patterns and considerations for attack aircraft and FAC(A) as in daylight operations apply. If no ground fire is encountered, it is preferred to have all aircraft lights on, if possible. Both the flare aircraft and the FAC(A) normally will have all of their lights on after rendezvous. Attack aircraft should turn on their lights as they call the FAC(A).

10.7.6.2 High Threat Tactics. In a high threat environment, the aircrew should utilize all available agencies and means to suppress the threat to protect the OV-10 as well as the attack aircraft. These agencies may include surface-to-surface SEAD fires from artillery, mortars, and naval gunfire, as well as electronic warfare measures such as airborne jamming or antiradiation missiles. Specific OV-10 tactics may include using the laser designator to mark the target from a long standoff distance. It should be noted that target detection and identification will probably be accomplished utilizing the FLIR system, and will be more difficult at increased range. The aircrew should make every attempt to minimize their exposure time to the threat.

In a high threat environment, it may not be necessary or advisable to illuminate the target with either airborne or surface-fire delivered flares. Many attack aircraft are equipped with night vision devices such as a navigation FLIR, targeting FLIR, night vision goggles, or a combination of these. Additionally, they are capable of utilizing a laser mark. The chances for surprise during the attack will normally be increased if no illumination is used.

10.7.7 Tactical Air Coordinator (Airborne) (TAC(A)). The mission planning information requirements for the TAC(A) are very similar to those for the FAC(A). The TAC(A), as an airborne extension of the direct air support center (DASC), performs many of the same functions as the DASC where they relate to assault support and offensive air support. Normally, the TAC(A) will be employed to provide these services to a regimental sized maneuver unit. Above all else, the TAC(A) needs to build as much situational awareness as possible prior to launch. This is done through the concept of planning everything from flight brief to debrief.

The first place to look when beginning the process of air strike planning is the air tasking order (ATO) and the special instructions (SPINS). These documents contain the basic framework and essential details of the TAC(A)'s mission and the missions of other aircraft that will be airborne at he same time. This includes aircraft that are designated to support the same unit as the TAC(A) and those supporting adjacent units. The TAC(A) must also be aware of any strip alerts and other aircraft that can be diverted to help the supported unit if necessary. The ATO will provide call signs, missions, time on target, ordnance, contact points, initial points, attack aircraft supporting the TAC(A)'s mission, and other assets available such as tankers, C^3I^2 assets, ground units, etc. A close look at the locations of these assets and time required in transit is necessary.

The TAC(A) must be aware of, and have plotted, the fire support coordination and airspace control measures that apply to the fire support coordination and airspace control measures that apply to the mission. These include the CPs, IPs, return to force (RTF) corridors, strike routes, helicopters, lanes, MEZ and FEZ locations, ACA's attack positions, etc. The type and quantity of information required to be familiar with and plotted will depend on the coordinated mission.

The communication plan being used will include frequencies, call signs, and color codes, as well as IFF codes, code words, visual signals, encryption capability, and covered capability.

Time permitting, a face-to-face coordination with as many of the units and agencies involved should be arranged. This becomes more difficult as operations get larger or longer. Some of the important units/agencies to coordinate with are maneuver units being supported, DASC and other C^3I^2 agencies, HC(A) and/or the flight coordinator.

Different problems and questions will arise with each specific operation. It is important to keep the plan as simple as possible. Some general questions the TAC(A) needs to consider include:

1. What is expected of the TAC(A)?

2. What are the timing requirements?

3. Where will C^3, GCE, other aircraft, and the enemy be?

4. Where does the TAC(A) need to be?

5. What means of communication are available?

Other information to be considered by the TAC(A) includes the supported unit's mission, the enemy, troops, and terrain as this information applies to the mission. Particular attention must be paid to all those

items having to do with fire support. Some of these include FSC measures, TGT list, supporting arms available (artillery, NGF, mortars), and the target precedence list.

Next, move to weather and find out what, if anything, could significantly affect your mission, then plan accordingly. Consider takeoff, en route, target area, return route, divert bases and possible affects on threats and ordnance fragged for the mission time frame. In planning for divert bases, include consideration for forward based EAFs to extend on station time.

Know your ingress/egress routes, CPs/IPs, target and threat locations. The TAC(A) must know friendly troop locations. If TAMPS imagery is available, review threat rings as well as radar terrain masking data for the route and target area.

The TAC(A) needs to coordinate with the TAOC, ABCCC, AWACS, AO, and DASC for any new or updated information. Have the proper information available and ready to use before getting airborne so cockpit tasking is reduced to a minimum.

Once the initial mission planning is complete, the TAC(A) needs to examine some OV-10 specific requirements. After looking at the mission, decide exactly what is needed to complete it. Items to be considered include ordnance, fuel, expendables, radios, FLIR, NVGs, binoculars, cameras, etc. Bear in mind that the TAC(A), in an emergency situation, may be required to take the FAC(A)'s mission. Since battlefield situational awareness is what the TAC(A) is all about, anything that detracts from SA will detract from the mission. Assuming the FAC(A) role, while sometimes necessary, will diminish the effectiveness of the TAC(A). One aircraft cannot perform both missions simultaneously. Regaining SA after switching from a TAC(A) to a FAC(A) and then back to a TAC(A) is very time consuming and difficult at best.

Execution of the TAC(A) mission will be extremely situationally dependent. As an extension of the DASC you could be called upon to:

1. Control a specific three dimensional portion of airspace

2. Act as a backup when the DASC becomes a casualty

3. Provide a vital link between the ground and the DASC, particularly in periods of heavy jamming or when disturbance precludes clear radio communications.

The first instance, when the TAC(A) controls a specific three-dimensional portion of airspace can be seen as the traditional role of the TAC(A). Here his job is to effectively coordinate with the FACs and FAC(A)s in his sector to ensure the effective flow of CAS aircraft through the air command and control system to the supported unit. To do this, he must effect communication with the DASC to ensure that aircraft are sent to his CAS stack so that they can be allocated in a timely manner. In this role, where he is working somewhat autonomously, the TAC(A) becomes responsible for the effective management of his stack, sending aircraft to the tanker as needed, and assigning aircraft with the optimal load out to the FACs as they are needed.

In the second method of employment, the TAC(A) serves as a backup to the DASC. Here he monitors all pertinent command and control nets to keep his SA as high as possible and remains ready to assume the role of the DASC should it become a casualty or have to displace. In this role, the TAC(A) would want to be on station long enough to build SA and be prepared to assume the DASC task.

In the third possible scenario, the TAC(A) acts as a conduit for optimizing informational flow within the command and control system. Here the TAC(A) needs to look at not only the doctrinal flow matrix, but also be creative. First it must be determined who really needs the information. The TAC(A) determines this in preflight planning. Address how to build redundancy into the system. Once this has been determined, the next phase is where to be best positioned to provide this service. During periods of heavy communications jamming or electromagnetic interference, it will be incumbent on the TAC(A) to be effectively positioned so he can effect communication with the supported unit and then pass that information up the chain whether it be to the DASC or to another agency within the system. The positioning of the aircraft will of course be threat dependent, but should be between a contact point and an initial point. This position allows the TAC(A) to maneuver for the most effective communication between the supported ground unit, the DASC, and inbound CAS aircraft. This use of the TAC(A) also puts him into an ideal position to assume a more comprehensive role should the DASC become a casualty.

10.8 HELICOPTER SUPPORT

Helicopter operations range from combat search and rescue (CSAR), tactical recovery of aircraft and personnel (TRAP), and medical evacuation (MEDEVAC) by a single helicopter to tactical and logistical flights of large formations of helicopters.

Since the flight characteristics, structure, and armament of transport and attack helicopters are not sufficient to evade, absorb, or suppress more than light enemy opposition, and since most helicopter operations are conducted within the small arms envelope, effective coordination of supporting arms is essential to mission success. OV-10 support for helicopter operations falls into the following categories:

1. En route escort of transport helicopters

2. Reconnaissance of the landing area

3. Landing zone briefing

4. Supporting arms coordination, including zone preparation, and suppressive fires during the helicopterborne assault.

10.8.1 Mission Planning. Prior to a complex helicopter operation, personal liaison must be established between the ground unit, air control agencies, and supporting helicopter and fixed-wing units involved. The tactical situation will determine the technique of support. Variation in employment methods requires knowledge of expected enemy opposition, weather conditions, number of helicopters employed, and the number of covering aircraft assigned. Preflight briefings should be as thorough as available information permits. This briefing should include, but should not be limited to:

1. General description of the entire operation, including the ground unit's scheme of maneuver and fire support plan

2. Helicopter corridors and alternates

3. Helicopter landing zone and alternates

4. The enemy situation, including antiair threats

5. Alternate plans of action for foreseeable weather conditions and changes in the tactical situation

6. Escort aircraft and escort responsibilities.

This information is concurrently disseminated in a ZIPPO (zone, inspection, planning, preparation, and operational evaluation) briefing. A typical format is shown in Figure 10-30.

10.8.2 Helicopter Escort. The OV-10 can provide effective helicopter escort by using its own ordnance and by coordinating supporting arms and attack aircraft assets. Artillery support may be planned for flak suppression, to lay smoke screens, and for zone preparation. Fixed-wing support may be used not only for any of the above but also for electronic countermeasures, fighter CAP, and en route escort. Attack helicopters provide quick reaction to enemy small-arms fire and can be employed to lay smoke screens (WP rockets); and to assist in landing zone preparation and fire suppression.

10.8.2.1 Low/Medium Threat. In a permissive/restrictive threat environment, the OV-10 can provide some of the firepower of jet aircraft with a reaction time similar to that of the helicopter gunship. A pattern should be flown that will permit an immediate attack on any ground position which fires on the helicopter formation. In general, altitudes of 3,000 to 4,000 feet AGL and airspeeds of 180 knots provide sufficient fields-of-view and maneuverability. The pattern flown may vary from a zigzag path behind the helicopter to a racetrack around them. When more than one OV-10 is provided, a continuous moving racetrack pattern is usually easiest to control. Attacks on either side, ahead of, or behind the helicopter formation are possible. Significant enemy activity may require four aircraft in the pattern. The relatively low altitude and airspeed of the OV-10 allows quicker target acquisition and a tighter pattern than that possible with most jet attack aircraft. Helicopter escort missions require the aircrew to keep continuously oriented and alert.

10.8.2.2 High Threat. In a high threat environment, helicopters can be expected to use terrain flying altitudes. The OV-10 aircrew can operate at the same altitude as the helicopters: 200 feet and below. Care must be taken not to fly over top the helicopter formations nor too near the formations. The escort aircraft at the same time must be in position to provide immediate support when called upon.

Prerequisites for any escort mission require a minimum of the following items:

1. A detailed intelligence brief, to include the plotting of all threats.

2. The helicopter's routes of flight (both primary and alternate routes). This information should include the proposed timing to each checkpoint.

3. A detailed map study of the route of flight and objective area.

4. Communications plan — EMCON procedures, code words, CHATTERMARK, and planned frequency changes.

5. Escort patterns to be flown and areas of responsibility.

GROUND UNIT MISSION
SUPPORT OF DATE:
SENIOR ALO CALL SIGN/FREQ
UNIT TO BE LIFTED CALL SIGN/FREQ
HC(A) CALL SIGN/FREQ
FAC(A)/TACA/AO CALL SIGN/FREQ
TRANSPORT CMDR CALL SIGN/FREQ
GUNSHIP CMDR CALL SIGN/FREQ
COMMAND and CONTROL HELO CALL SIGN/FREQ
FIXED WING CALL SIGN
NR AND TYPE AIRCRAFT IN SUPPORT OF MISSION
PICK-UP COORDINATES:
LZ DESCRIPTION:
DROP COORDINATES
LZ DESCRIPTION:
DROP COORDINATES (ALT)
LZ DESCRIPTION (ALT)
ROUTES
ASSAULT FM PRI/SEC UHF PRI/SEC
GROUND TACTICAL/LZ CONTROL CALL SIGN FREQS: PRI/SEC
FIXED WING CONTROL FREQ FM/UHF
WEATHER MINIMUMS/ALTERNATE PLAN
PICK UP TIME/LATEST ACCEPTABLE
H HOUR/LATEST ACCEPTABLE
ARTY PREP TIME/END OF MISSION
ARTY CALL SIGN/FREQ
NGF PREP TIME/END OF MSN /
NGF CALL SIGN/FREQ /
F/W PREP TIME/END OF MSN /
F/W NR OF FLIGHTS/ORD /
CALL SIGNS/FREQ /
F/W CAP/TOS/ORDNANCE/FREQ / / /
RULES OF ENGAGEMENT/CLEARANCE TO FIRE
ENEMY SITUATION
Specific tasks desired of TAC(A)/FAC(A)/A.O.
TOS/reliefs/VR/special equipment etc.

Note: This is a guide only. Ensure that you have a thorough understanding of the concept of the operation and of the detailed logistical planning required for your squadron to support it properly.

Figure 10-30. Typical ZIPPO Briefing Guide

6. Helicopter scatter plan and rendezvous points if engaged by air or ground threats.

7. Fire support plan.

8. SAR safe areas.

9. A prelaunch face-to-face briefing with all participants present or, at a minimum, the helicopter mission commander.

The flight:

1. Some considerations — helicopters are concerned not only with the ground threat, but the air threat as well. The work load of the OV-10 escort crew is multiplied in that we now have to provide coverage for both threats.

2. Detailed coordination with the mission commander (lead transport helicopter) during planning will include pattern selection. The following formations are described to provide OV-10 crews with a starting point. Modifications will be necessary as the mission dictates.

a. Detached Escort. Detached escort normally describes a pattern flown by a section of OV-10 in which the lead will maneuver the section (using uncalled turns) approximately 1 to 3 nm from the helicopters. At this distance, the OV-10 are never too close (thereby giving away helicopter position) or never too far (20 seconds to 1 minute) to provide timely suppressive fires on ground/air targets. This method permits the OV-10 to visually check front, flank, and rear areas. Care should be taken never to overfly the helicopter, parallel their course, or overfly the same checkpoint a number of times. When crossing the helicopter route of flight for maneuvering purposes, it should be done obliquely, or at a right angle. Remember, it isn't necessary to see the helicopters at all times: it is necessary to know where they are. This is accomplished by detailed map study and thorough knowledge of their phase lines, as well as good basic crew coordination.

Navigation of the section is the responsibility of the lead aircraft's aerial observer.

b. Combined Escort. When escorting large numbers of transport helicopters (and assets permitting), the OV-10 may be used in conjunction with other support aircraft to enhance helicopter coverage.

One possible mix calls for a section (or division) of helicopter gunships to cover the front and rear areas of the flight, being concerned primarily with suppression of enemy ground fires. Second, a section of OV-10, when flying in combat spread, has two primary responsibilities: because of the unique observation characteristics of the OV-10, the crews will generally be able to spot enemy ground or air threats much sooner than the crews of the other aircraft in the flight, therefore, it is their responsibility to alert the flight for enemy distance and bearing in order for appropriate action to be taken. The second responsibility is destruction of enemy armed helicopters. The third element in the mix is fixed-wing escort. These aircraft (AV-8s, FA-18s) are obviously needed to deal with fixed-wing threat. They can be employed in a proximity escort mode, orbiting at low altitudes at preselected CPs, or as CAP (Figure 10-31).

10.8.2.3 Night Helicopter Escort.

The OV-10 crew cannot expect to provide the same type of detached or proximity escort at night as during the daytime. Response times for airborne or ground threats could be much longer as acquisition ranges at night may increase. Missions for the OV-10D in the night helicopter escort role could include CIFS, SAC, or multisensor route reconnaissance as the mission dictates. Additionally, the OV-10D could be used in a FLIRCAP role (para. 10.12.2) protecting a FARP or other vital area.

10.8.3 Landing Area Reconnaissance.

Although selection of landing areas is the responsibility of the helicopter flight leader and the supported unit commander, the OV-10 aircrew must have a knowledge of the most desirable features of such an area to enable them to evaluate proposed sites rapidly and accurately and make appropriate recommendations. The helicopter landing area must meet criteria for location, size, approach, and topography.

10.8.3.1 Location

1. Terrain must support the ground unit scheme of maneuver, i.e., provide accessibility to objective, ease of link up with friendly forces, and ease of reinforcement and supply.

2. The known or probable level of enemy resistance must be acceptable, given the mission priority.

3. Terrain must provide cover or concealment for the helicopter assault.

4. A landing zone within range of suitable supporting arms is preferable.

10.8.3.2 Size

1. The landing zone must be large enough to permit rapid buildup of combat power within the landing area. When considering the number of

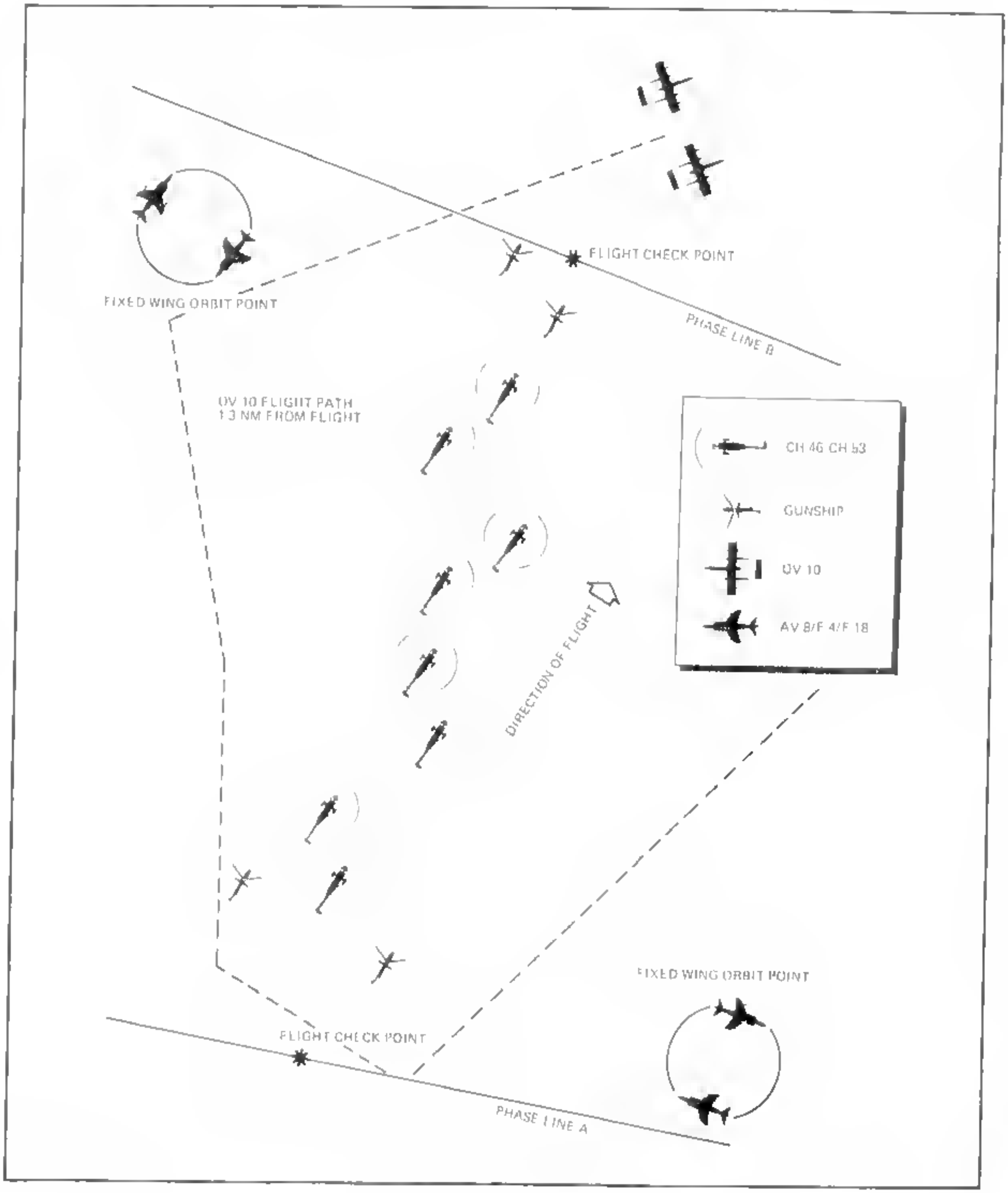


Figure 10-31. Combined Escort

helicopters that can be landed in a zone, allow a circle 90 meters across for each transport and 60 meters for each utility or attack helicopter.

2. If the approach or retirement lanes are over obstacles, or if visibility is poor, plan additional space for obstacle clearance.

10.8.3.3 Approach and Retirement. The landing area approach and retirement corridors should be:

1. Aligned with the wind for maximum lift capability

2. Concealed from enemy observation.

10.8.3.4 Soil Condition and Topography. The landing area itself should be:

1. Clear of boulders, small trees, stumps, and other obstacles

2. Free of holes and swampy areas

3. As level as possible

4. Free of dust and debris, which not only cause reduced visibility in the zone but may reveal the landing to the enemy.

10.8.4 Landing Zone Briefing. Overall coordination of helicopter support operations is improved by utilization of a TAC(A). The TAC(A) is responsible for the preparation and approach phases which include controlling available supporting arms and providing direction and information for all air elements. The TAC(A) provides a landing zone brief to the transport commander marking the zone if necessary, and then stands by until the insert is complete and helicopters are clear. A typical landing zone briefing guide is provided in Figure 10-32. This format is adaptable to most types of helicopter missions, including MEDEVAC, extract, and resupply missions.

10.8.5 Landing Zone Preparation and Suppressive Fires. Landing zone preparation is normally accomplished just prior to the arrival of the assault helicopter formation. Strikes are called on the landing zone itself only if enemy obstacles to helicopter landing are expected. Heavy ordnance should be avoided to preclude cratering or seeding duds in the actual landing area. Detonation of antipersonnel

MISSION NO. ______
COORDINATES ______ TACAN RADIAL/DME ______
UNIT CALL SIGN ______
FREQUENCY PRI UHF ___ FM ___
SEC UHF ___ FM ___
LZ MARKING ______
WIND DIRECTION/VELOCITY ______
ELEVATION/SIZE ___ / ___
OBSTACLES ______
FRIENDLY POSITIONS: DIRECTION/DISTANCE ___ / ___
ENEMY POSITIONS DIRECTION/DISTANCE ___ / ___
LAST FIRE RECEIVED: TIME/TYPE ______
DIRECTION OF FIRE/DISTANCE ______
APPROACH/RETIREMENT (RECOMMENDED) ___ / ___
PRECEDENCE/CAUSE INJURY (MEDEVAC) ___ / ___
PERS/EQUIPMENT EVACUATED (RETROGRADE) ___ / ___

CLEARANCE TO FIRE DIRECTION/DISTANCE ___ / ___

FOR FINAL APPROACH CONTROL, CONTACT ______
MY POSITION ______ MY ACTION: ______

Figure 10-32. Typical Landing Zone Briefing Guide

nities can be accomplished with 20-mm guns, instantaneous fuzed HE rockets, CBU-55, or napalm. Attacks should be directed at surrounding areas that provide the best cover for the enemy (hedgerows, tree lines, trenches).

Since the zone preparation may not completely destroy enemy resistance in the area, concealment of the inbound assault wave and continuing flak suppression are important. If terrain does not provide adequate concealment, a smoke screen should be laid about 30 seconds prior to the arrival of the assault wave at the zone. Wind effects must be taken into account to ensure the smoke does not drift over the zone. Flak suppression is normally provided by helicopter gunships accompanying the transports. Minimum weather conditions for jet attack aircraft operating in support of helicopters is considered to be not less than a 1,000- foot ceiling and 3-statute mile visibility. The ordnance must be compatible with weather conditions to preclude fragmentation damage to aircraft. If the situation requires flying helicopter support with adverse weather prevailing, the number of aircraft in the immediate area must be strictly limited. Extreme vigilance is required when operating helicopters and attack aircraft under restricted visibility conditions.

After the troops have landed, the TAC(A) should remain within radio range (threat permitting) to provide immediate response to CAS requests. Caution is required in using proper ordnance loads under these conditions, since helicopters in the zone are much more susceptible to fragmentation than are the troops dug in around them.

10.9 CLOSE-IN FIRE SUPPORT

If the need arises for the OV-10 to employ its organic weapons, the ordnance-carrying capability of the aircraft makes it an effective weapon delivery platform. When very close support is desired by troops in contact (within 50 meters), it is often difficult to assure the necessary attack aircraft precision to break contact through decimation of enemy forces. Weather often restricts the optimum utilization of attack aircraft. Even when utilization of attack aircraft is anticipated, the suppressive fire capability of the OV-10 (which invariably arrives on the scene first) can, if properly employed, minimize friendly losses and drive the enemy to static defense positions.

After the situation is stabilized and employment of attack aircraft and/or artillery is feasible, the OV-10 crew will break off its brief offensive role and assume its control mission to assure destruction of the enemy. The ground unit commander determines the proximity to friendly positions at which specific ordnance will be cleared. However, this should be a considered judgment and, in most instances, advice is readily accepted from the OV-10 crew to assure both maximum enemy kills and friendly safety. Except in the most dire emergencies (and with friendlies having reasonable cover), 20mm should not be employed within 30 meters, M60 fire should not be brought within 15 meters. These parameters of safety (safety zones) assume conditions of guns firing true, well-experienced pilots, positive visual contact with the supported unit throughout all runs, and, of primary importance, adjusting the strafe toward these minimum distances, rather than initiating at the edge of safety. When using 2.75-inch rockets for close support, it is important that the increased accuracy provided by the scarfed motor be recognized. The firepower of the OV-10 is inspiring and extremely useful in close; however, the total destructive capability of CAS is much greater in comparison and more appropriate in most situations.

10.10 ANTIHELICOPTER OPERATIONS

In general, tactics against armed helicopters are designed to take advantage of the OV-10 high relative speed, maneuverability, and firepower. For further information refer to NWP 55-6-OV10A/D, Vol. II.

10.11 CONVOY ESCORT

The OV-10 convoy escort mission is flown by a section of aircraft during the day or single aircraft at night. It consists of a visual reconnaissance of the convoy route and relay of significant sightings directly to the convoy commanders. Positive radio communication is a necessity. Convoy escort is flown with varying patterns in a similar manner to local VR, observing all hazards that might restrict convoy movement. Unscheduled road repairs, oncoming traffic, groups of civilian pedestrians, road conditions, and possible ambush sites should be subjects of scrutiny. When vehicles break down, the convoy commander will decide whether to halt the entire convoy or to have repair vehicles only remain with the disabled vehicle. If the entire convoy stops, VR should be intensified in the immediate area of the convoy, since it is more vulnerable at this time. If the convoy commander elects to split his forces and leave repair vehicles with disabled vehicles, the aircraft can continue coverage of both segments, except for the most extended delays. Vulnerability of the stranded segment is greatly increased when unexpected delays in convoy movement occur just prior to darkness, and the deteriorated situation can often be salvaged by OV-10 relay of the situation with requests for flare ships and security forces. If the convoy becomes engaged, the

OV-10 may be used to suppress fire and to control supporting arms to counter the enemy threat. See Figure 10-33 for a Planning Checklist.

10.12 AIR DEFENSE OPERATIONS

10.12.1 VISCAP. The AIM-9 sidewinder armed OV-10 is capable of limited visual combat air patrol (VISCAP) assignments. There are primarily two situations that would involve the OV-10. First, that a large and unexpected enemy air attack is in progress at which time all VISCAP-capable aircraft report to preplanned, low-altitude, orbit points. Second, that the OV-10 is incorporated into an overall antiair warfare (AAW) plan designed to defeat an anticipated enemy air attack. In either case, the OV-10 would be responsible for visually sighting, reporting, and engaging (with missiles), if possible, any enemy aircraft flying through its assigned area.

This is most easily accomplished in section (ensuring mutual support) and through cueing from external sources such as the LAAM, LAAD, TAOC, EWC, or FEZ or other VISCAP aircraft.

The section's area of responsibility should be sufficiently small to enable rapid response to a given threat. Terrain or area to be covered will dictate the physical boundaries of the VISCAP sector.

10.12.2 FLIRCAP. Unlike a VISCAP, a FLIRCAP is single aircraft mission which utilizes the NOS on the OV-10D for threat acquisition in an AAW role at night. The width of the sector for a FLIRCAP should be reduced compared to a VISCAP and oriented toward a threat axis. The responsibility for situational awareness during a FLIRCAP mission will be placed more on the NAO/SAC(A) than on the total crew. For further discussions on crew coordination and night reconnaissance, see paragraph 11.3.

10.13 PARADROP OPERATIONS

The OV-10 can be configured to carry four paratroops and a safety rider. Drop modes include level free-fall drops and static-line drops from either a level or a pop up delivery. The paradrop mission places great responsibility on the pilot for two reasons. Proper handling of aircraft emergencies is critical, since paratroops do not have a low-altitude escape system such as the ejection seat. The pilot is also solely responsible for locating the drop zone and ensuring that paratroops exit at the proper point given the existing winds.

10.13.1 Premission Planning. All the mission planning considerations discussed in Chapter 1 apply to the paradrop mission. Use the METT-T factors to determine a recommended drop made (level or pop-up). Avoid unnecessary overwater legs and align the last leg of the route with the forecast surface winds and with the long axis of the drop zone, if possible. For training missions, ensure that a NOTAM has been published, and that a SAR helicopter and safety boats (if drop zone is close to water) are available. Aircraft gross weight for performance data should include 225 pounds for each paratroop. If the mission permits, reduce fuel load as necessary to assure single-engine climb capability for the ambient conditions forecast.

10.13.2 Briefing. A briefing for a paradrop mission consists of a jumpmaster's brief and a flight leader's brief, followed by questions and general discussion. The jumpmaster and the flight leader then brief their subordinates on detailed execution of the mission.

10.13.2.1 Jumpmaster's Brief

1. NOTAM

*2. Pick-up point/time

3. Corrected manifest

4. Jumpmaster/assistants/safety riders

5. Number/composition of sticks

6. Type jump/drop altitude

7. Drop zone location/map/aerial photographs

*8. Alternate drop zone information

9. Drop time/latest acceptable

10. Desired routing/restricted fire plans

*11. DZ Commander call sign/frequency

*12. DZ control signals

*13. Safety boat call sign/frequencies

*14. Supporting arms call sign/frequencies

10.13.2.2 Flight Leader's Brief

1. Flight line security

2. Loading procedures and time

*If applicable

1. CONTROLLING HEADQUARTERS

2. ANY UNIT AFFECTING MOVEMENT

3. CONVOY LEADER

4. UNIT TO BE MOVED

5. REACTION FORCE

   A. UNIT, LOCATION, TYPE WEAPON, NO. OF PERSONNEL
   B. HELICOPTER TRANSPORT (NUMBER AND TYPE)
   C. ESCORT (NUMBER AND TYPE)

6. INTERNAL SUPPORTING ARMS CONTROLLERS

   FAC ______ ______________ POSITION IN CONVOY
   FO ____________________ POSITION IN CONVOY
   NGFO _________________ POSITION IN CONVOY

7. DEPARTURE SUPPORTING ARMS CONTROLLERS

8. DESTINATION COORDINATES/ETD

9. (CONTROL POINTS) COORDINATES, DESIGNATIONS, ETA

10. REST AREAS

11. NUMBER AND TYPE VEHICLES

12. POSITION OF ORGANIC SUPPORT WITHIN CONVOY

13. TYPE COLUMN CLOSE/OPEN/INFILTRATION

14. HIGH RISK CARGO: TYPE AND LOCATION IN CONVOY

15. COMMUNICATION:

UNIT	CALL SIGN	FREQUENCY
CONTROLLING HQ	__________	__________
CONVOY LEADER	__________	__________
UNIT TO BE MOVED	__________	__________
DASC	__________	__________
TATC	__________	__________
TAR	__________	__________
TAD	__________	__________
TA	__________	__________

Figure 10-33. Convoy Escort Checklist (Sheet 1 of 2)

UNIT	CALL SIGN	FREQUENCY
ORGANIC SUPPORTING ARMS	________	________
ALO	________	________
FO	________	________
NGLO	________	________
TAC(A)	________	________
FAC(A)	________	________
HC(A)	________	________
CIFS	________	________
TRANSPORT (CH-46/53)	________	________
SUPPORTING ARTILLERY	________	________
NAVAL GUNFIRE SHIPS ON LINE (FSA)	________	________
FIXED-WING	________	________
REACTION FORCE	________	________

16. GROUND SIGNALS

    SMOKE
    PANELS
    LIGHTS (CONVOY LEADER/CMDR & CRITICAL VEHICLES)
    FLARES
    MIRROR

17. RULES OF ENGAGEMENT

18. ACTION OF CONVOY

    AMBUSH
    DISABLED VEHICLES
    MINES

19. PREVIOUS ROAD/BRIDGE RECONNAISSANCE CHECK

20. ENEMY AIR DEFENSE

21 ENEMY GROUND SITUATIONS

22. REMARKS

Figure 10-33. Convoy Escort Checklist (Sheet 2 of 2)

3. Jumpmaster checks: ICS, lights, horn, ready for taxi, ready for takeoff

4. ICS: "SAFELY AIRBORNE" call, ICS/radio interference

5. Use of safety belts en route

6. Primary and alternate routes, cruise altitudes and airspeeds

7. Forecast DZ weather and winds

8. Aircraft maneuvers prior to and during jump

9. Light signals

10. Jump altitudes and airspeeds

11. Jumpmaster and jumper duties

12. Safety rider duties

13. Emergency procedures

(a) Use of emergency horn

(b) Fire on deck

(c) Forced landing/ditching

(d) Serious emergency in flight

(e) ICS failure/jump light failure

(f) Sick jumper

(g) Inadvertent parachute deployment in aircraft

(h) Fouled deployment bag with hung jumper.

10.13.3 Aircraft Preflight and Loading. The paratroop transport configuration consists of the basic cargo flooring plus a backrest for the safety rider, one safety belt for door jumper, an intercommunication headset, a parachute cable, side panel covers, and a troop signal and warning assembly. A gunners belt must be provided for the safety rider.

Check the following equipment before preflighting the aircraft:

1. Cargo bay door — REMOVED

2. Drop tank — REMOVED

The FPU-3/A tank may be carried with the tail fin assembly removed.

3. Static line — CHECK SECURITY, no frays

4. Jump lights and horn — CHECK

5. ICS (cargo bay) — CHECK

6. Safety belts — Check PROPER INSTALLATION (aft belt attached to second point from doorway)

7. Rough edges of doorway, side panels and floor — TAPED.

8. FLIR CABLES — STOWED (AFC 96 or 97 A/C)

Complete all aircraft start and pretaxi procedures before loading personnel. The squadron will designate a loading supervisor to ensure that all personnel approach the aircraft from the rear and that loading is orderly. The safety rider is loaded first followed by the jumpers, all facing aft. The jumpmaster is last to load and wears the ICS headset. The jumpers normally will not hook up before taxi and may remain unhooked until just prior to takeoff.

Note

A combat weapons and individual equipment (CWIE) bag may be worn only by the man at the door. Mixed loads of paratroops and cargo, such as door bundles and mount-out boxes, are not recommended.

After loading is complete, make a check of the ICS, signal lights, and emergency horn with the jumpmaster. It is recommended that the hydraulic pump also be activated at this time to ensure that it is not confused with the emergency horn. Obtain confirmation from the jumpmaster and the loadmaster prior to taxi. Make another ICS check just before takeoff to ensure all jumpers are now hooked up and ready prior to moving the condition levers to T.O./LAND.

10.13.4 Takeoff and En Route Procedures. Conditions permitting, make a no-flap takeoff, since this provides best single-engine performance.

Note

Maximum performance takeoffs are permissible only for emergency or mandatory

missions, when required by ambient runway conditions.

After takeoff, climb to above 400 feet as quickly as practical and notify the jumpmaster. All jumpers, except the jumpmaster and the safety rider, may remove their safety belts at this time. Since this is the lowest acceptable altitude for emergency bail-out by paratroops, conduct as much of the mission as possible above the altitude, threat permitting. While en route, advise the jumpmaster of arrival at prebriefed checkpoints. Avoid turbulence and airspeeds above normal cruise, if possible.

Note

Maximum permissible airspeed with the cargo bay door removed is 300 KIAS.

10.13.5 Jump Procedures. If operationally feasible, make a practice run across the drop zone for positive identification of the zone and for a final wind check by dropping a wind direction indicator (WDI) or streamer.

Provide verbal warnings at 10 minutes, 5 minutes, 2 minutes, and 15 seconds prior to drop. The ready (amber) light is turned on at the 2-minute warning. At this time the jumpmaster passes the headset to the safety rider and then dons his helmet, which has been held by the jumper behind him.

10.13.5.1 Wind Drift Correction. A proper correction for wind drift is vital to the safety and success of the paradrop mission, and in the OV-10 it is the pilot's sole responsibility. For drops from about 1,000 feet or less, displace the drop point 100 meters into the wind for each knot of surface wind. Stated another way, if the aircraft is approaching the zone on the windline at 180 knots, delay the drop 1 second for each knot of surface wind. At 120 knots, delay 1-1/2 seconds per knot of wind.

For drops at high altitudes, use the following formula:

$$D = KAV$$

D = drift in meters

K = a constant: 4.2 for personnel parachutes, 2.6 for cargo parachutes

A = altitude in hundreds of feet

V = an average of the wind velocity at 500-foot intervals from the surface up to the drop altitude.

Note

Do not underestimate wind drift. It is easier for the parachutist to drive downwind to the zone than to hold into the wind as he drifts over the zone.

10.13.5.2 Static Line Drops. Paradrops may be static line or free-fall drops. With the use of a static line, 700-foot AGL minimum must be maintained to conduct the drop safely. A safety rider will be utilized during static line jumps to retrieve the static lines and bags and to ensure jumper safety.

WARNING

Do not jump using static lines when airspeed is above 130 knots indicated airspeed, since the strength limit of the parachutes will be exceeded. In an emergency, the secondary manual chute is the only safe way to jump if speed cannot be reduced below 130 KIAS.

CAUTION

If static lines cannot be retrieved, a landing without flaps or reverse thrust is recommended. Skidding turns, low-speed flight, and flaps may cause the static lines to whip, which could cause damage to antennas, booms, and stabilizers.

For level, static line drops, recommended airspeed is 100 to 110 KIAS. This airspeed establishes a nose-high attitude, assisting the egress of the paratroops. Static line jumpers should push out slightly to their left (right side of aircraft) to increase separation from previous jumpers' static lines and bags. Helmets with visors or goggles should be worn to protect head and eyes from possible contact with static lines and hardware. A feathered engine will cause ends of static lines to drift slightly toward the dead engine but not enough to affect jumping safety, if the aircraft is maintained in balanced flight.

The pop-up, static line drop permits ingress to the drop zone at the low altitudes that may be required by the antiair threat or the weather. The steep, nose-high delivery attitude provides a desirably tight stick and easy exit from the aircraft for paratroops. Ingress into the zone should be made with the power levers locked

by the friction lever to maintain 180 knots. This allows the pilot to locate and operate the jump light switch during the pop-up without having to control throttle movement. Too fast an airspeed on ingress will result in a delayed green light and excessive exposure time, since the airspeed will be above 130 knots at the desired jump altitude.

A 2g to 3g pullup to 50° to 60° nose-high is commenced at the center of the drop zone (or as corrected for the wind as detailed in paragraph 10.13.5.1). After the initial pullup, maintain 1g or slightly less. Although this results in a steepening pitch attitude, it permits faster egress from the aircraft by the jumpers. At 700 feet with not more than 130 knots airspeed, turn on the green jump light and call "JUMP, JUMP, JUMP" over the ICS. The jumpmaster immediately releases his safety belt and exits the aircraft. The remaining jumpers exit as soon as the man in front of them is clear. All jumpers should be able to exit within 5 seconds. When the safety rider calls "JUMPERS CLEAR" on the ICS, secure the jump light and begin recovery prior to decelerating through 100 knots. Recover utilizing a wing-over type maneuver with coordinated rudder and aileron, but no elevator. Slow airspeeds of 70 to 80 knots are not unusual at the top of this maneuver; therefore, a neutral elevator is required to prevent a possible stalled or spin entry condition. As the nose slices through the horizon, smoothly input opposite rudder and aileron to level the wings and arrive at an attitude of 30° to 45° nose low. Again caution should be used when loading the elevator at this point until the airspeed has increased. This recovery attitude will allow for a comfortable descent back to an egress altitude of 200 to 300 feet AGL. Steeper nose-low attitude recoveries will require increased-g to achieve the same level-off altitude. (Aircrew should review Section 4, Flight Characteristics, and Section XI, Part 6, Flight Characteristics Data, of the NATOPS Manual prior to pop-up paradrop operations.)

WARNING

Climb angles in excess of 60° may only allow 3 to 4 seconds between maximum allowable jump speed and the recovery airspeed point. Any jumpers who have not exited the aircraft at the initiation of recovery (jump light out) will remain in the aircraft. If the jump process cannot be aborted and jumpers are still exiting the aircraft at recovery airspeed (100 knots) the pilot should keep the wings level and use slight forward stick to fly the aircraft back to the horizon. Caution should be used in reloading the elevator until a safe flying airspeed is obtained.

When conditions permit, clear of the drop zone, slow to 120 knots and instruct the safety rider to recover the bags and lines. The safety rider shall check his gunner's belt attached prior to releasing his safety belt. The safety rider reports when recovery of the bags is complete, then refastens his safety belt until landing. Lateral form section drops are dictated by DZ size and tactical situation.

10.13.5.3 Free-Fall Drops. Jumps without the use of a static line may encounter a normal tendency for the feet to rotate upward from slipstream. If time and equipment permit, a backout, face-forward exit will preclude a subsequent head-down chute deployment. This does not apply to static line jumps. Minimum safe egress altitude for free-fall is 1,500 feet AGL.

10.13.5.4 Cargo Drop. Cargo deliveries can be accomplished at relatively low altitude and high speeds. The cargo should employ a G-13 or G-14 parachute and be equipped with a non-breakway static line. Once the cargo is inserted in the aircraft the safety rider must ensure that it is properly secured and that good ICS and light checks are made. The safety rider will require about a 6-minute warning to unstrap and reposition the cargo for drop. A second warning should be given about 1 minute out. Drop is executed when the pilot turns on the green jump light. Run-in altitude should be 200 feet AGL with 180 knots. This altitude and airspeed is maintained for a level drop. After the cargo is deployed the aircraft can be slowed to allow the safety rider to pull in the static line. Cargo deliveries can be done in conjunction with pop-up paradrops. The run-in would be in section. However, at the drop zone the cargo aircraft would remain at 200 feet while the paradrop aircraft pops. The recovery for the cargo aircraft would be a level exit from the zone.

10.13.5.5 Emergency Procedures. Emergencies with jumpers aboard are particularly important, because the pilot must always be aware of the fact that the jumpers are not provided with their own zero/zero ejection capability. In general, if an airborne emergency occurs and there is any question of the ability of the aircraft to fly, or the safety of the jumpers in the cargo bay, the pilot should gain sufficient altitude to ensure a safe jump and have the jumper exit the aircraft over the most favorable terrain available. Likewise, if a ground emergency occurs, any jumpers embarked should immediately exit the airplane until the problem is resolved. For either of these occasions, the signal is the emergency horn. All jumpers shall be briefed that the only meaning

of the horn is: ALL PERSONNEL EVACUATE THE AIRCRAFT IMMEDIATELY.

10.13.5.6 Engine Failure on Takeoff. If a climb to 400 feet cannot be achieved and conditions permit, make a forced landing or ditch.

WARNING

If a successful landing looks doubtful at any time, EJECT.

10.13.5.7 Hung Jumper Procedures. In the event that a parachutist has a static line malfunction in the door and is being dragged by the aircraft, take the following action:

1. The pilot will immediately climb (at about 110 knots) to 2,500 feet, remaining well inland and/or downwind from any body of water.

2. Notify the departure airfield to alert the standby helicopter to rendezvous with the jump aircraft.

3. The parachutist will indicate consciousness by placing one or both hands on top of his helmet.

4. The parachutist shall not activate his reserve until he has been released from the aircraft.

5. If the parachutist is conscious and his reserve parachute is ready for activation, the towing line is cut immediately. Once the jumper has been released, keep him under constant observation during his descent. Orbit over the parachutist and be prepared to provide the standby helicopter with information relative to the location of the parachutist.

6. If the parachutist is unconscious or his reserve parachute is not ready for immediate activation, he is pulled as close to the aircraft as possible and secured. If landing is inevitable with a hung jumper, a grass or earth strip is preferred to concrete. To avoid dragging behind the aircraft, the parachutist should be cut loose as soon as the safety rider determines he is on the ground. Thought should be given to remaining airborne, allowing the jumper time to regain consciousness.

10.14 SENSOR DELIVERY

The OV-10 was primarily designed as a counter-insurgency aircraft. One of the most important missions in a counter-insurgency operation is the employment of remotely monitored ground sensors. Sensors are designed to monitor the presence of enemy forces or equipment through various electromechanical methods. The following advantages are acknowledged through sensor employment.

1. Once implanted, sensors do not require security forces to safeguard them, thus reducing the total combat force requirements.

2. Sensors can be implanted by aerial delivery means in a minimum amount of time with less logistic support than that required for insertion of reconnaissance patrols.

3. Sensors are self-sufficient for months at a time and are expendable, thus reducing the combat casualties associated with reconnaissance patrol operations.

4. Sensor detection can be continuous for the battery life of the sensor. Automatic monitoring equipment also can be employed. This circumvents the human fatigue problem (one man can simultaneously monitor dozens of separately located geographic points).

5. The intelligence information gathered is in the real-time category and can be used for the targeting of supporting arms.

The OV-10 can participate in the following sensor operations:

1. Conduct visual and photographic reconnaissance of the optimum coordinates for sensor implantation to cover likely enemy routes of travel.

2. The OV-10 can deliver and/or coordinate the aerial delivery of sensors. For those OV-10As incorporating AFC 20, provisions have been made for the KB-18A strike camera to photographically record the sensor release point. The OV-10D has the capability of using the FLIR to record deliveries.

3. Monitoring of sensor outputs using the AN/USQ-46(A) radio frequency monitor set (PORTATALE), as provided for by AFC 20.

10.14.1 OV-10 Sensor Employment. Reconnaissance patrols and the forward outposts along the FEBA help provide the ground commander with intelligence on the location and size of the enemy threat. Manpower constraints may reduce the number of patrols and outposts available to cover both the FEBA and exposed flanks. However, by using seismic sensors to cover the

exposed flanks and any key avenues of approach, the ground commander can mass his assets on one front and yet maintain flank security. Properly deployed sensors enable the ground commander to detect enemy movement and buildup early enough for friendly forces to react in a timely manner. Sensors dropped along or beyond the FEBA are generally unnecessary. However, certain S-2/G-2 requirements may dictate a sensor mission along or beyond the FEBA. For such a mission, planning should include:

1. Detailed route planning for primary and alternate routes

2. Route deception

3. ECM

4. MiGCAP

The seismic sensors (ADSIDs) are the only type of sensors delivered by the OV-10. The acoustic sensors are no longer in the sensor control and management platoon (SCAMP) inventory. SCAMP personnel will brief the aircrews on the number of sensors to be dropped in a string, and the desired distance between sensors. Once implanted, sensors can supply the location, size, speed, direction, and type of enemy movement for immediate destruction fires. Or by computing the speed and direction of movement, a prediction can be made as to the probable location of enemy forces for targeting purposes. Sensor employment operations can be divided into three basic areas.

1. Mission planning

2. Sensor loading and delivery

3. Map/photographic annotation and postmission reporting.

10.14.2 Mission Planning. SCAMP personnel will be the primary unit responsible for briefing the aircrews on sensor missions. SCAMP planners, with assistance from S-2/G-2, will provide a specific target location, number of strings, number of sensors per string, and distance between sensors. Maps (1:50,000) of the target area are required for the detailed planning to follow. SCAMP personnel will be present for briefing the aircrews, loading the sensors, installing the PORTATALE, and ensuring the equipment is operational.

Careful consideration should be given to several factors when formulating the mission plan. The plan may be very simple in a low-threat environment and become progressively complex as the threat level increases. Specific planning considerations include:

1. Route planning

2. Alternate routes

3. Route deception

4. Weather requirements — go/no-go criteria

5. Use of KB-18A camera or FLIR

6. Number of OV-10 drop aircraft required

7. Escort requirements — ordnance load

8. SAM/AAA suppression

9. Fighter CAP.

Each of these areas should be thoroughly examined to ensure mission success. The tactics employed should be consistent with the enemy threat. In planning, consideration should be given to the fact that sensors add considerable drag, thus negatively affecting cruise speeds, fuel endurance, and available g because of lower IAS. Sensor missions are critically important to the ground commander. Because the mission is generally conducted behind the FEBA in a low-threat environment, flight crews must not take the mission too lightly and must be diligent and thorough in all aspects of flight planning.

10.14.2.1 Sensor Mission Planning Example. The following example is for a half-day operation with the objective of implanting four sensor strings (5 ADSIDs per string). The sensors are to be implanted along a dirt road, 7 kilometers behind the FEBA, on the flanks of a battalion which is in a defensive posture. The threat is small arms, SA-7, and possibility of HIND or fixed-wing aircraft.

Two OV-10s are configured with two PMBRs. If an OV-10A with AFC 20 is used, an AN/USQ-46(A) PORTATALE and the KB-18A camera should be used. The sensor aircraft will carry one AIM-9 each. If an air threat exists, the sensor aircraft are dependent on escort or MiGCAP protection because navigation duties severely degrade lookout doctrine.

One escort OV-10 armed with 2.75and 5-inch HE and WP rockets and two AIM-9s is required. The aircraft is manned by an experienced FAC(A) aircrew. A secondary function of the escort aircraft is to act as control/coordination for the sensor aircraft.

Note

It must be reiterated that the foregoing example is only a recommendation for a specific set of circumstances, and is not necessarily applicable or desirable for all sensor missions.

10.14.3 Sensor Loading and Delivery. The successful aerial delivery of sensors depends on proper loading and precise flying. It is the drop pilot's responsibility to preflight his sensor load and accurately deliver the individually coded sensors on the designated target coordinates. It is imperative that the pilot preflight each PMBR, noting which stations are loaded and checking that the release order corresponds to the loading plan. A pilot kneeboard sensor card (Figure 10-34) should be used to record all pertinent data for the afteraction report. The pilot should compute all delivery, takeoff/climb, and cruise data because of the high parasitic drag index of the PMBR/sensor load. This is especially critical when operating in hot weather from short runways. Consult the sensor delivery tables for delivery parameters and the Sensor Spacing Time Versus Distance Table (Figure 10-35) for computing the release data.

Since the OV-10A/D gunsight lacks sufficient mil depression capability for proper mil lead-angle settings, the gunsight is impractical for sensor deliveries. However, a proven technique, while in level 1-g flight, is to depress the bomb button when the target (aim point) passes the nose of the OV-10D or passes the pitot tube on the nose of the OV-10A aircraft. Additionally, for the OV-10D, by using the FLIR as a gunsite, delivery accuracy can be greatly improved. First, place the FLIR in the "FORWARD" mode. Then, dial the "mil" setting into the "GIMBAL DEPRESSION" on the "RECEIVER/TRANSMITTER CONVERTER CONTROL." As the cursor crosses the start point for the sensor string, sensor drop is initiated. Practice sensor drops are essential to develop the necessary pilot technique. When the pilot's proficiency is within desired accuracy limitations, he can be assigned to perform the actual mission.

The ADSID sensors activate automatically upon a successful implant. Verification can be obtained by having the drop aircraft make a low pass (100 to 200 feet AGL) over the sensor string, provided the enemy threat will permit such a pass without undue hazard. As the aircraft makes its verification pass over the sensors, either the NAO/SAC(A) will watch the PORTATALE to determine sensor activation, or SCAMP will monitor their equipment to determine activation. Each string is recorded (active or inactive) on the kneeboard sensor card for the mission debriefing. This data is invaluable for future ground monitoring and might reveal problem areas that can be resolved by the ground monitoring station (such as a wrong sequence in a string, or sensor code not activated — presumed sensor damage).

It should be noted that total reliance cannot be placed on the KB-18A or the FLIR to fix the location of the implanted sensors, because of the possibility of malfunction. Cross checks should be employed as necessary.

An important consideration when delivering ADSID sensors is the striking angle with the ground. The more nearly vertical the impact angle, the greater success rate of the implants. A grazing angle caused by releasing too low an altitude AGL, or by terrain sloping away from the sensor trajectory, will probably result in the sensor not implanting at a sufficient angle and being unable to perform. As a general rule, do not conduct low-altitude sensor drops when the terrain slopes away. It is preferable to make the sensor runs in an uphill direction provided the terrain and threat do not constitute a serious hazard.

The radar altimeter is very useful for indicating the aircraft altitude AGL. Sensors dropped in a downhill direction will fall long, and sensors dropped uphill will impact short. The radar altimeter can be used to negate these factors.

10.14.4 Map/Photographic Annotation and Postmission Reporting. Although proper mission planning and sensor delivery techniques are the most important facets of sensor aerial delivery operations, the sensor data transmitted cannot be efficiently utilized without a thorough documentation of the mission results.

The ground units which monitor and utilize the sensor data must know exactly where each individually coded sensor has been placed. Standard map and photograph annotation procedures should be used noting at least one prominent reference point, aircraft heading, airspeed, altitude, sensor code number/string number, and other pertinent information (such as strong winds, and late or early releases). If the pilot is required to plot the sensor fall and impact coordinates, he should thoroughly familiarize himself with the appropriate sensor employment manuals and prediction calculation methods. Otherwise, trained photographic interpretation personnel will process the photographic data accordingly.

The mission is complete only when the sensor liaison officer for the supported unit, with whom the

SENSOR LOADING/DELIVERY CARD

PILOT ______________________ DATE ______________________

AIRCRAFT MODEX ______________________ UNIT SUPPORTED ______________________

STATION NO. ________ STATION NO. ________ STATION NO. ________

A/A37B-3 PMBR RELEASE ORDER

L	5	2	6
	3	1	4

R

Aft

Release Order	String No.	Aircraft Station No.	Code	Release Altitude (MSL)	Release Heading (MAG)	Active (Check)	Drop Coordinates
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

DELIVERY

Airspeed ____________ KIAS

Altitude ____________ Feet AGL

Interval ____________ m

CHECK LIST

1. Camera DOWN
2. Master Arm ON
3. Station DROP
4. Camera START
5. Ordnance PICKLE

TAKEOFF ________

LAND ________

TORQUE ________

TEMP ________

Vmc ________

Figure 10-34. Sensor Loading/Delivery Card

SPACING DISTANCE (METERS/FEET)	AIRSPEED (KNOTS) 150	160	170	180	190	200
	TIME (SECONDS)					
250/825	3.30	3.10	2.90	2.75	2.60	2.50
200/660	2.64	2.48	2.32	2.20	2.08	2.00
150/495	1.98	1.86	1.74	1.65	1.56	1.50
100/330	1.32	1.24	1.16	1.10	1.04	1.00
50/165	0.66	0.62	0.58	0.55	0.52	0.50

Figure 10-35. Sensor Spacing Time Versus Distance

initial liaison was conducted at the start of the mission, has all the information he requires. Furthermore, established wing or group directives may require the submission of a formalized report with information copies to be supplied to all concerned.

Note

The sensor mission will continue to grow in importance as new types of aerial delivered sensors/equipment are developed, and as newly developed enemy antiair warfare weapons restrict the use of normal visual reconnaissance methods. Sensor tactics must be modified to fit any given set of circumstances, and the preceding procedures information is subject to change as new equipment is introduced and tactics are perfected.

10.15 MESSAGE DROPS

Because of various tactical situations, it may be considered necessary to drop messages to combat units in the field. The OV-10 has proved to be very appropriate for message delivery. The message is delivered by means of a foot-operated, spring-loaded message drop door system installed in the aft cockpit. The drop door is large enough to accommodate messages and various small objects required by units in the field. The techniques used for delivery vary, depending upon the terrain over which the drop is to be made. If possible, a level run should be used, although because of surrounding terrain, a dive-type delivery may be required. Level runs are made at an airspeed of 130 to 150 knots, at approximately 100 feet above the surrounding terrain. The drop requires coordination between the crew of the OV-10. Since the rear seat man has no means of judging when to drop, he must depend on the pilot to give him a standby call and an accurate mark. A dry run is advisable in order to develop the required coordination. It has been found that the most accurate drops occur when the pilot gives his mark just as the target passes under the nose of the aircraft.

10.16 FORWARD SITE OPERATIONS

Once the landing force has established itself ashore, or the squadron has been deployed to an inland area of operations, the OV-10 can expect to be forward based. This forward basing will be to serve all interests of the operating force. The OV-10 will be operated out of short tactical strips, constructed by our engineers; suitable stretches of hard surface or dirt; or grass fields. Any of these options will allow the unit either direct or immediately accessible contact with the ground commander being supported, or with helicopter and AV-8 assets also forward based. Timeliness of information, response to a ground unit's request for any of the VMO missions, flexibility of movement, and overall mission coordination and effectiveness will be increased.

With the OV-10 STOL capability, operations from any of the unimproved areas pose no major hindrance to operations. There are several factors that must be considered when selecting an area for forward site operations.

10.16.1 Size. In choosing a site for operations, we must consider runway length, width of the runway area, support facilities room, bivouac areas, and parking/maintenance areas. Runway length will be critical and affected by several factors. The length of the runway will depend on the weather/temperature conditions, expected fuel and ordnance loads to be carried, and the condition of the runway itself. In general, the runway length should at least provide for sufficient room for a fully internally fueled aircraft, armed minimally with two rocket pods, to take off and clear a 50-foot obstacle, using STOL parameters (refer to NATOPS planning data for more exact figures). The width of the runway area cannot obviously be narrower than 40 feet, and should allow room on either side to safely turn an aircraft around while on the ground. The experience level of the aircrew involved can be considered, but a minimal wingtip clearance of 20 feet should be considered, because of wind and other factors. Sufficient room at the sides of the runway should be available for use as a bivouac, supply, and maintenance area. Hide sites, camouflaged from above, should be constructed to enhance survivability and freedom from detection. If constructed, dimensions should minimally be 50 feet per side, with the camouflage covering at least 20 feet above the ground. This will allow for sufficient room to turn an aircraft around while under cover.

10.16.2 Accessibility. A site should be able to be reached with minimal difficulty. This will enhance the response time when radio communications are out or poor, and runner or vehicles are used. It will also aid in the critical resupply of necessary items, such as fuel and ordnance, and will facilitate in later movement or further buildup.

10.16.3 Grass Field Operations. When working off of a grass strip, consider the following factors:

1. California bearing ratio (CBR) of the ground

2. Length of grass or crops on field

3. Roughness of field — potholes, rocks, stumps, etc.

4. Gradient of field — crowned is good for water runoff, whereas, a field with several depressions will hold water and hinder operations during rainy weather

5. Condition of field around runway area to be used for parking.

10.16.4 Road Operations. When working off of a hard surface or dirt road, consider the following factors:

1. Length and condition of the road — cracks, faults, ditch, crumbling concrete, etc.

2. Width of road surface on which to land — absolute minimum of 16 feet.

3. Drop-off at edge of road — should be shallow and not cause directional control problems should a tire leave the surface.

4. Presence of curbs, or any abrupt edge, should be avoided.

5. Composition of road surface — should be dependable in all weather conditions.

10.16.5 Flight/Aircraft Considerations. The following factors should be considered concerning aircraft handling and flight from forward sites:

1. Rate of descent should be closely monitored when landing on grass.

2. Directional control in confined strip areas.

3. With absence of meatball, do not "spot the deck" at the end of the runway, as you will land short.

4. Positive rotations during takeoffs are a must.

5. When operating off a road lined by trees, wind will generally channel down roadways, but will revert to its correct direction above the treetops so expect a crosswind upon breaking the top.

6. When landing between high trees, the tops should be broken farther out from the point of landing. Aircraft should be flown below the treetops, in close-to landings, to eliminate lateral control inputs caused by crosswinds.

7. Minimal use of brakes on grass, especially wet, as aircraft will slide or dig in.

8. Thorough understanding of aircraft parameters in use. Reactions and responses to immediate action emergencies should be thoroughly covered and planned before hop begins.

10.16.6 Forward Site Markings. The MATCS light and mobile team, or MWSS engineers will be capable of providing landing site markings for both day and night operations. The following diagrams are provided to demonstrate optional marking configurations for day operations and lighting configurations for night operations (Figures 10-37 and 10-38). The Marine wing support squadron representative will be able to assist

you in determining their capability to support your operations at the remote site. For night operations, the use of a Fresnel lense optical landing system, although not mandatory, will greatly aid air training evolutions.

10.16.7 Light and Mobile Team (LMT). Each Marine air traffic control squadron is capable of fielding up to eight LMTs. The LMT's equipment is typically mounted in one or two high mobility multipurpose wheeled vehicles (HMMWV's) and consists of communications equipment, a global positioning system (GPS) receiver, and a NAVAID. An LMT can control aircraft up to 40 miles from its position at an air facility or air site. Typically, an LMT is manned by an ATC officer, three enlisted ATC tower controllers, and three ATC non-radar approach controllers. Each MATCS Detachment provides two LMTs. When LMTs are employed, the capabilities of the MAATCS Detachment are degraded.

10.17 KB-18A STRIKE CAMERA

A KB-18A strike camera (Figure 10-36) can be installed in the OV-10A aircraft. A message drop door is installed in those aircraft not having the camera installation. The 3-inch focal length strike camera is located on the floor of the observer's cockpit forward of the control stick and provides 180° panoramic film coverage along the line of flight. System components consist of the KB-18A camera, camera control unit, and the camera operate switch and indicating lights.

The camera is mounted vertically in a cradle mechanism which, when operated by the observer, extends or retracts the camera. The camera doors on the underside of the aircraft open automatically when the camera is extended and close when the camera is retracted. The control unit is located in the cargo bay and the pilot-controlled camera operate switch and indicating lights are located on the pilot's windshield bow. The control unit contains various switches, electronics, and protective devices for control and operation of the camera system.

10.17.1 Vertical Strip Photography. Vertical strip photography employing the KB-18A airframe-mounted camera (AFC 20) can overcome some of the problems involved in obtaining true vertical photographs for use in photo-mosaic maps. Although the KB-18A was intended as a strike camera to record aerial delivered sensor release points, when required it can be moderately successful as a reconnaissance camera, if sufficient lighting conditions exist and if certain preflight requirements are complied with. Refer to Sensor Employment in Chapter 10. The OV-10A can successfully accomplish a limited amount of vertical strip photography for photo-mosaic mapping by proper use of the KB-18A camera. Refer to the OV-10A NATOPS Flight Manual (NAVAIR 01-60GCB-1).

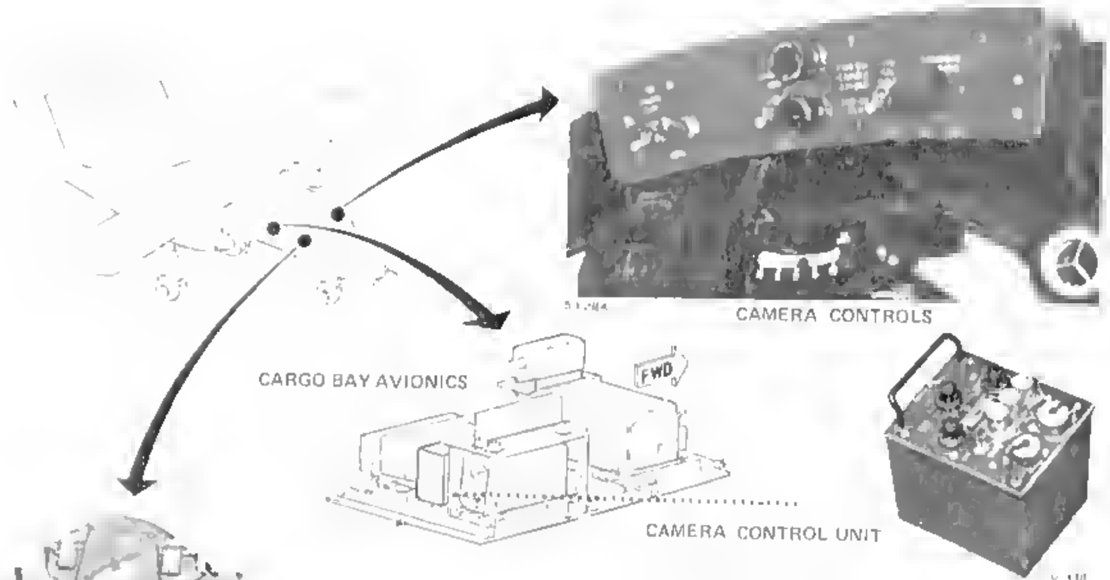
Vertical strip photography is used to create photomosaic maps when the existing map coverage is outdated or nonexistent for a particular area. The strips should have at least 25° of side overlap and the pilot must track a straight line of flight parallel to the preceding strip, spacing his 180° turns accordingly. It is recommended that photo runs be made in upwind/downwind directions with respect to the actual winds aloft. To run crosswind would require the pilot to crab the aircraft into the wind causing a stair-step pattern for each strip rather than the preferred straight-edge strip. Since the lateral scan angle is 40° the pilot can trigonometrically compute the required lateral separation on each photo run depending on the altitude chosen. The optimum altitude (AGL) depends on the resolution and scale desired.

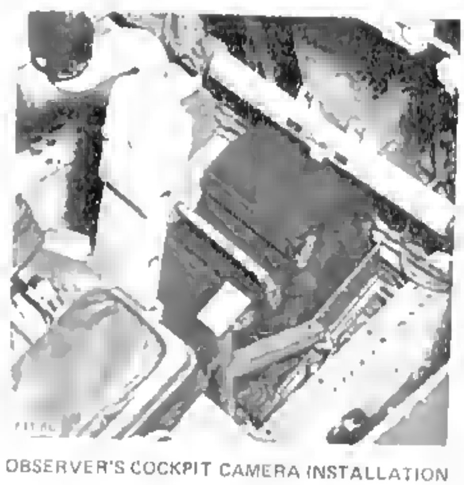
Use Figure 10-39 to determine proper altitude for the desired scale and ground covered by the vertical center portion of the photograph. Film canisters of all types shall be clearly marked with date, mission number, sequential listing of targets photographed (identify by grid coordinates), and names of the aircrew.

Although the KB-18A is a panoramic, moving film camera with a scan angle of 180° forward and aft, the useful portion of each individual photograph is limited because of angular distortion. Only the sector of 40° fore and aft, centered perpendicular to the camera lens axis, is useful for mapping purposes. A 60-percent overlap is desired for mosaic composite strips and also for stereo coverage to aid in detailed photo interpretation. To obtain the desired 60- percent minimum fore and aft overlap, the camera control unit cycle switch must be set (1, 2, or 4), depending on the altitude (AGL) and the true groundspeed. Low altitudes and fast groundspeeds require more cycles per second to achieve the minimum required overlap.

The aerial exposure index (AEI) on the camera control unit should be set on the appropriate setting (40, 64, 80, or 200), depending upon the exposure rating of the film being used. However, experience under moderate to poor lighting conditions indicates that the next lower setting should be set.

The camera control unit overrun time should be set (0 to 20 seconds at 2-second intervals plus a 30-second setting) depending on the length of strip desired, altitude (AGL), groundspeed, and the area to be covered. A secondary consideration is the amount of film loaded versus the number of strips to be exposed with the cycle switch setting. Although the





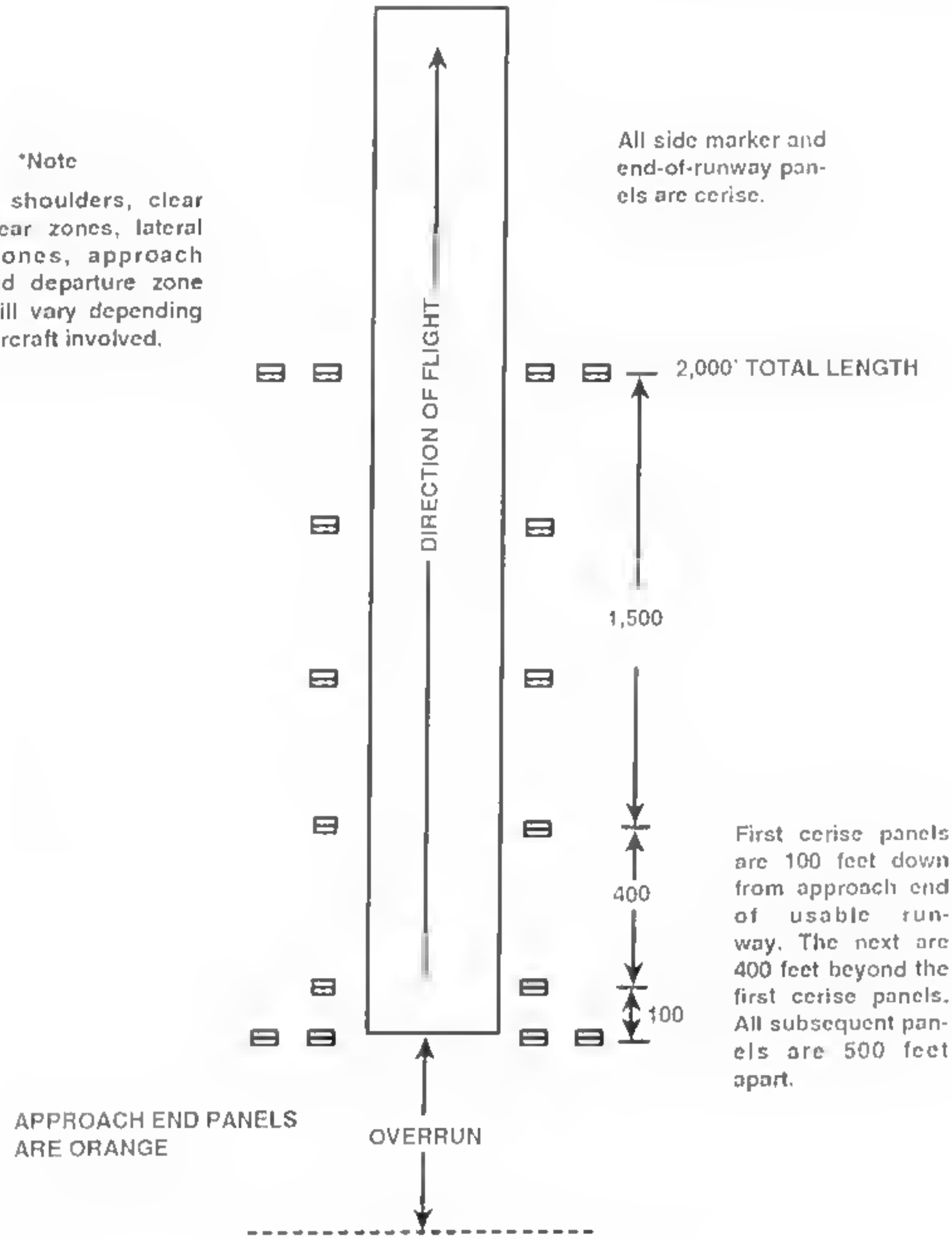
Leading Particulars Camera System, KB 18A

ITEM	CHARACTERISTICS
Type	Rotary prism, panoramic, moving film
Scan angle	180 degrees forward and aft, 40 degrees lateral
Film format size	9.40 by 2.25 inches
Operating voltages	115 volts ac, 400 Hz, +28 volts dc
Modes of operation	
• Autocycle or remote operate	1,2, or 4 cycles per second
• Aerial exposure index (AEI)	40, 64, 80, 200
• Overrun time	Inoperative
Prism	Double dove
Lens	3 inch, f/2.8
Aperture range	f/2.8 through f/22
Slit width range	0.02 to 0.20-inch
Relative shutter speeds	Approximately 1/400 to 1/4000 second
Film	
• Type	70mm, Type II,perforated
• Aerial exposure index	40, 64, 80, or 200
Film Capacity	250 feet (approximately 300 exposures)
Altitude, operating	0 to 50,000 feet
Weight	
• Camera body	16.0 pounds
• Magazine/film	12.5 pounds
• Camera control unit	5.0 pounds

Figure 10-36. KB-18A Strike Camera

*Note

Overrun, shoulders, clear areas, clear zones, lateral safety zones, approach zones and departure zone criteria will vary depending on type aircraft involved.



Note

Marker panels are erected vertically to enable the pilot to readily observe the markings when the aircraft is on final approach. At the discretion of the mission commander, the panel markers may be erected to provide for landing in the opposite direction by folding the panels in half.

Figure 10-37. Option A — Landing Zone Markings (Day) (Sheet 1 of 2)

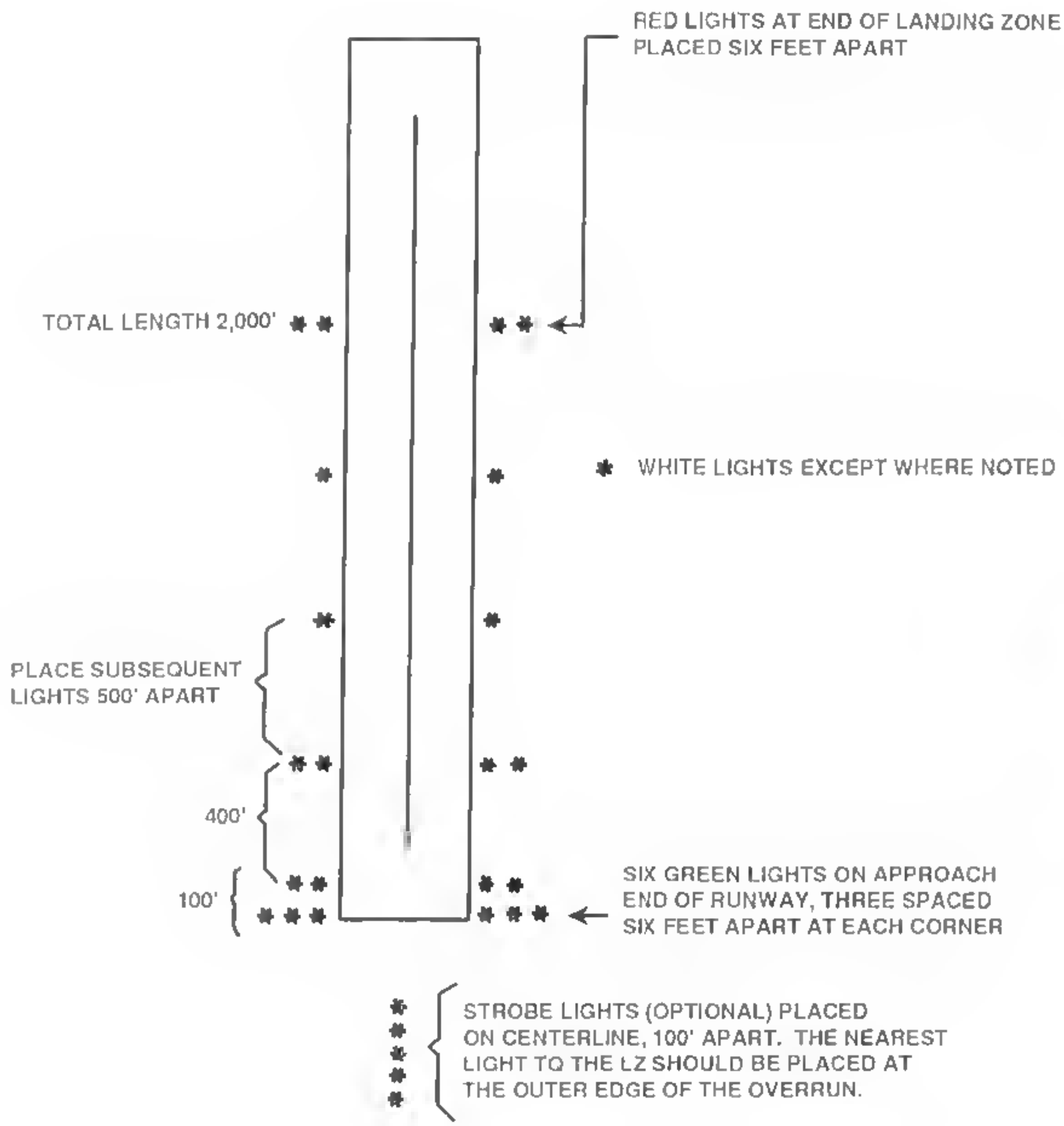
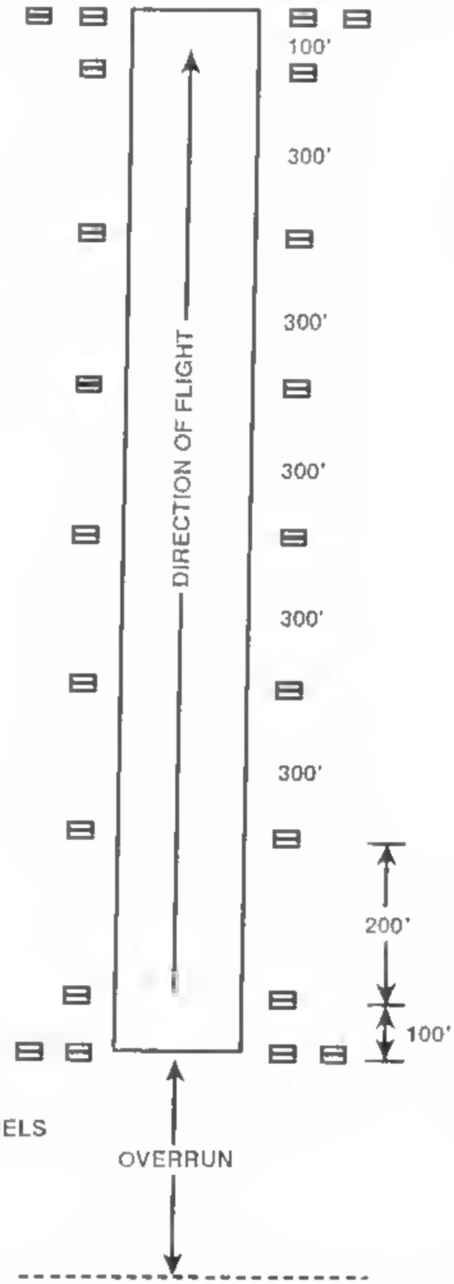


Figure 10-37. Option A — Landing Zone Markings (Night) (Sheet 2 of 2)

All side marker and end-of-runway panels are cerise.

*Note

Overrun, shoulders, clear areas, clear zones, lateral safety zones, approach zones and departure zone criteria will vary depending on type aircraft involved.



First cerise panels are 100 feet down from approach end of usable runway. The next are 200 feet beyond the first cerise panels. All subsequent panels are 300 feet apart.

APPROACH END PANELS ARE ORANGE

Note

Marker panels are erected vertically to enable the pilot to readily observe the markings when the aircraft is on final approach. At the discretion of the mission commander, the panel markers may be erected to provide for landing in the opposite direction by folding the panels in half.

Figure 10-38. Option B — Landing Zone Markings (Day) (Sheet 1 of 2)

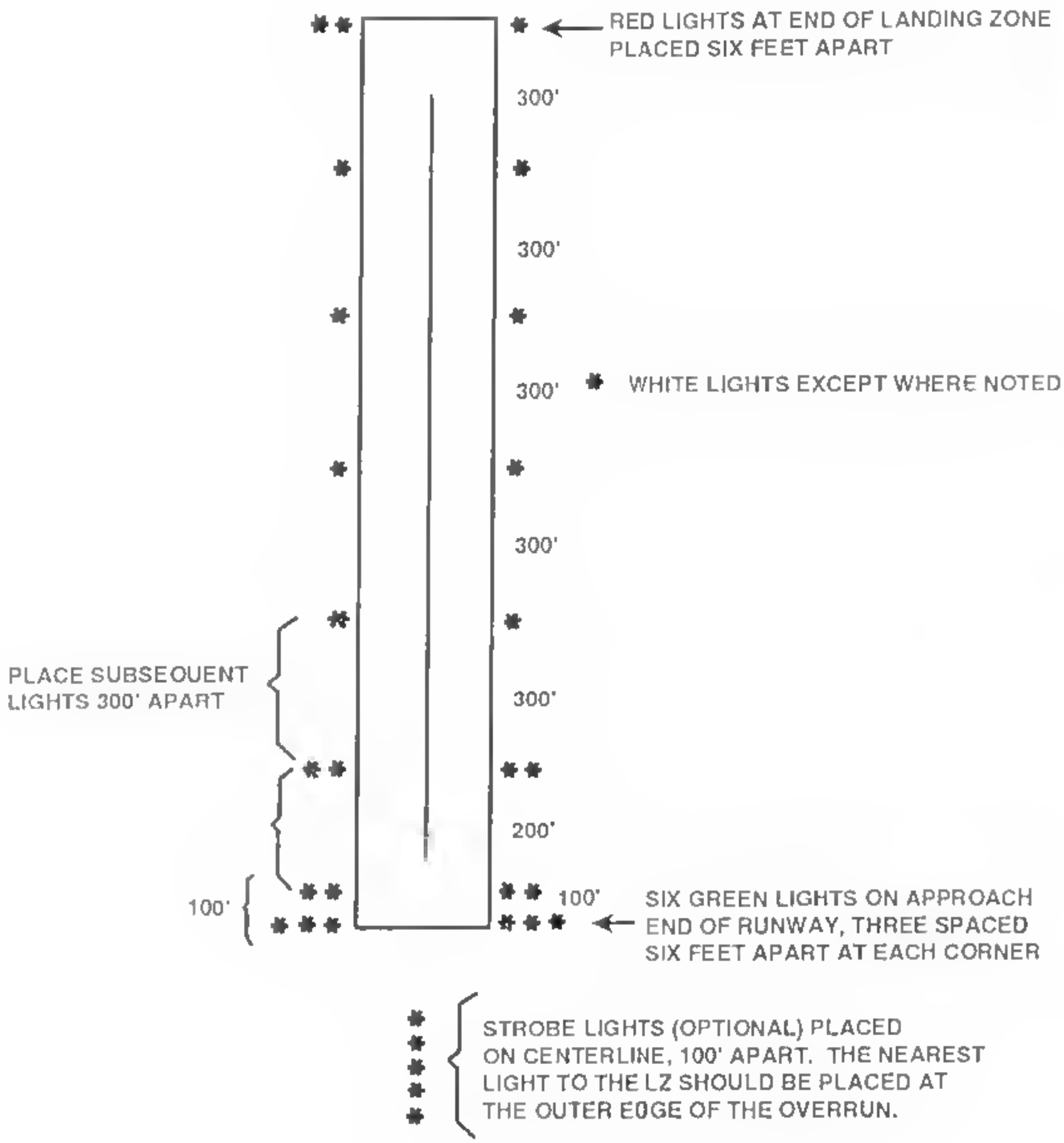


Figure 10-38. Option B — Landing Zone Markings (Night) (Sheet 2 of 2)

ALTITUDE	SCALE	GROUND COVERED (M)
50	1:204	11
100	1:408	23
150	1:612	34
200	1:816	46
300	1:1224	69
400	1:1632	93
500	1:2040	116
600	1:2448	139
700	1:2857	163
800	1:3265	186
900	1:3673	209
1000	1:4081	233
1500	1:6122	349
2000	1:8163	466
2500	1:10204	582
3000	1:12244	699
3500	1:14285	816
4000	1:16326	932
4500	1:18367	1049
5000	1:20408	1165
10,000	1:40816	2331

Figure 10-39. Data for KB-18A Camera

KB-18A has a magazine capacity of 250 feet (approximately 300 exposures), the roll of film normally available through the supply system is only 100 feet in length. This reduces the practical number of exposures available to approximately 120, minus those consumed during loading and preflight camera checkout. For example, a 4-cycle-per-second setting combined with a 10-second overrun setting consumes 40 exposures per strip and it is improbable that three complete strips could be obtained.

When performing vertical strip photography, the cloud ceiling must be higher than the aircraft altitude to achieve 100-percent coverage. The desirable lighting conditions are essentially the same as for oblique photography except that shadows are advantageous when using black and white film because they provide contrast required for a truer perspective.

During clear days at the lower latitudes, or during the summer months at the higher latitudes, the best time for vertical black and white photography is from sunrise plus 1 hour to 2 hours before high noon or from 2 hours after high noon to 1 hour before sunset. During the winter months, or at the higher latitudes, shadows are long enough to provide good contrast from 1 hour after sunrise to 1 hour before sunset. Color film inherently has more flexibility because colors provide effective contrast. The best color quality is obtained on a clear day at high noon, which also results in the shortest shadows and the best ground detail. Shadows at high noon also give a north-south direction to the pictures.

After completing the mission, the pilot should note on the aircraft maintenance discrepancy form that the KB-18A is to be unloaded and the film processed.

Note

> It is imperative that the film be printed backwards (negative reversed from the normal aspect) because the double dove prism of the KB-18A reverses the photo image twice while the camera is functioning.

Finally, annotation of the completed mosaic photomap must be made, indicating direction of north, scale, and two reference grid coordinates (preferably in opposite corners of the map).

10.18.2 Threat Considerations. The tactical constraints stated for the visual reconnaissance mission apply equally to aerial photography. Generally, photographic quality is best at lower altitudes, but this must be measured against increased vulnerability to the enemy threat. Even in a permissive threat area, avoid multiple passes and repetitions orbiting over a known or suspected enemy position. In a sophisticated threat environment, consider use of a low-level ingress and pop-up to obtain the required photographs. If this tactic is to be used, obtain wide-angle lenses (approximately 35mm focal length for 35mm cameras) and high-speed film.

10.18.3 Preflight of the KB-18A

1. Ensure that the camera is loaded and equipped with the appropriate filter.

2. Raise and lower the camera in the cradle mechanism to ensure proper operation.

3. Check the camera doors for proper operation and with the camera in the down position check to ensure the glass cover over the lens is clean.

4. Ensure that the camera control box in the forward part of the cargo bay is correctly set. The usual settings are as follows:

   (a) Frames/sec set at 1 or 2. This gives the number of frames exposed per second.

   (b) Overrun mode set at 1. This will allow one additional frame to be exposed after the cockpit switch is released.

(c) Air exposure index (AEI) (similar to ASA) set at 80. Lower settings will increase the contrast. Experience has shown that 200 should NEVER be used. With power applied to the A/C the POWER ON CAMERA EXTEND light should illuminate with the camera extended. The END OF FILM light should blink as each frame is taken with the CAMERA ON switch activated. It will light continuously when all film is exposed. When the camera is retracted the POWER ON CAMERA EXTEND light should go out. There are 385 usable frames per 350-foot roll of film.

CHAPTER 11

Terrain Flying

11.1 INTRODUCTION

When the antiair threat precludes the FAC(A) from operating at the low and medium altitudes where the OV-10 is most flexible and effective (1,500 to 10,000 feet), the pilot must examine the possibility of flying underneath the threat envelope. Whether or not this is feasible depends on the nature of the threat, the terrain, and the support available.

The following discussion of terrain flying outlines procedures and techniques that will enable the pilot and observer to navigate safely and effectively at low altitudes. Terrain flying is the tactic of utilizing terrain, vegetation, and manmade objects to enhance survivability by degrading the enemy's ability to detect the aircraft visually, optically, and electronically. It generally refers to visual navigation below 500 feet AGL. There are three distinct subcategories:

1. Low-level flight is flight along a preplanned route consisting of straight-line route segments between identifiable checkpoints. A constant airspeed is maintained, and altitude is generally steady over each route segment. Continuous orientation is necessary between checkpoints. Low-level flight is well suited to day and night operations in the OV-10.

2. Contour flight (low-altitude tactics) is flight at altitudes that conform to the contours of terrain and vegetation. Varying altitude and airspeed are used to take advantage of available cover and concealment. Properly performed contour flight requires continuous map orientation. Contour flight is well suited to daytime operations, but night contour flights require a high level of training, favorable terrain, and either moonlight or special night-vision equipment. The OV-10 crew must be proficient in day operations down to 50 feet AGL.

3. Nap-of-the-Earth flight is flight as close to the Earth's surface as vegetation or obstacles will permit, while generally following the contours of the Earth. The pilot preplans a broad corridor of operation, based on known terrain features, that has a longitudinal axis pointing toward his objective. The pilot varies his altitude, airspeed, and route within the preplanned corridor to take maximum advantage of the cover and concealment afforded by terrain, vegetation, and manmade features. This type of flight is extensively used by helicopters that normally attempt to remain below the surrounding vegetation. The following discussion is limited to low-level and contour flight.

Terrain flying is not a mission itself but simply a technique to increase survivability so that the mission can be performed. Through proper planning and training, the OV-10 aircrew will arrive at the place and time required by its mission.

The lower the altitude required to remain below the threat envelope, the greater the problems. As the flight altitude decreases, planning requirements increase dramatically. Crew coordination is more critical, orientation more difficult, and obstacle clearance more demanding. As a general rule, use the highest altitude consistent with the threat.

11.2 PLANNING CONSIDERATIONS

Proper planning for a terrain flight is the single most critical requirement for a successful sortie. Initial planning is based on the METT factors as amplified in the following paragraphs. When this is completed, the crew is ready to plot the route, define crew responsibilities, and plan contingencies. Flexibility will be directly proportional to preplanning.

11.2.1 Mission. If at all possible, have a face-to-face briefing with the supported unit to ensure that you understand the mission. Determine the mission priority, the weather minimums, and the degree of flexibility you have in planning the route.

11.2.2 Enemy Situation. A thorough intelligence briefing is critical to mission success. You must know the capabilities of the antiair threat by rote. In addition to the known and probable locations of enemy troops

and weapons, you must be familiar with the enemy's preferred method of deployment of antiair weapons.

11.2.2.1 AAA Threat. There is *no* advantage to operating at low altitude if AAA is the primary or the only threat consideration. Low altitude does not greatly degrade AAA except for terrain masking that can be used to achieve tactical surprise and to break engagement by loss of line of sight. While operating at low altitude, however, there are some basic tactical principles and tactics that can be employed to minimize the AAA threat. They include: plan and fly around known AAA concentrations; avoid lines of communication, intersections, populated industrial areas, and generally all low flat terrain. You should seek high rugged terrain and areas covered with dense vegetation, and vary your heading a minimum of 20° every 5 to 10 seconds. If low flat terrain must be negotiated, ultra low altitude with indirect masking and backdrop blending is imperative.

11.2.2.2 SAM Threat. One of the main advantages of operating at low altitudes in a sophisticated SAM environment is the large percentage of SAM systems that can be negated or degraded to a less than optimum mode. The SA-2 and SA-4 systems have little or no capability against a 100-foot AGL target. The SA-3 is forced into a much degraded mode. However, the SA-6, SA-7, SA-8, SA-9, and their follow-on systems (SA-6B, SA-11, SA-13, SA-14) are formidable threats even at treetop level. Antitank guided missiles (ATGMs) have some capability against the OV-10 at low altitudes. That is not to slight the capabilities of any non-Soviet SAM systems (i.e., HAWK, Rapier, Crotale, and so forth). Navigational tactics to minimize the SAM threat at low altitude include: planning and flying around known SAM rings; maximizing terrain masking, both direct and indirect; and capitalizing on meteorological conditions to degrade SAM optics. In those cases where mobile systems are involved, use best intelligence and terrain available to circumnavigate likely threat concentrations. High rough terrain and dense vegetation enhance tactical surprise, restrict their fields of fire, and provide obstructions to hide behind. Optical tracking opportunities can be reduced by putting the sun at your back or navigating in mountain shadows.

Note

When operating within the effective range of enemy air defense weapons, the use of suppressive fires should be considered.

11.2.2.3 Air-to-Air Threat. Soviet trained pilots rely greatly on GCI. The low-altitude profile degrades GCI, may shrink air-to-air weapon envelopes, and creates a terrain hazard for the intercept aircraft. If sufficient terrain masking is available, a low altitude can effectively neutralize GCI capability; in which case, interceptors are forced into less efficient visual caps.

A gun shot is difficult against a 1g target at any altitude. At low altitude the problem is obviously compounded. Navigational tactics to minimize the MiG threat at low altitude include maximizing terrain masking, planning short navigational legs, capitalizing on meteorological conditions, and maintaining a relatively high energy state. Dark rugged terrain, mountain shadows, hugging the base of a ridgeline, and not silhouetting the aircraft against the sky will increase the visual acquisition problem for the interceptor.

11.2.3 Friendly Situation (Troops). Plot restrictive air and fire plans on your maps. Locate friendly units, fire support bases, and fire support coordination and control lines (see FMFM 7-1). If radio reports will be required during the mission, estimate where you will be able to make radio contact with the receiving unit. Friendly radar and visual CAP locations and call signs should be noted.

11.2.4 Terrain. Make a thorough map study. Note the presence of built-up areas, main roads, railroads and canals, and cleared or lightly vegetated areas.

Plan to avoid all of these, if possible, as these areas will usually be occupied or defended. Clear areas provide increased tracking time for enemy surface-to-air weapons. Highlight the high ground on your map to make shapes more readily definable when airborne. Be well aware that terrain itself is one of the greatest threats while flying at a very low altitude. Operating at such altitudes requires only a momentary distraction to spell instant disaster.

Examine recent aerial photographs for evidence of unplotted powerlines or other wire hazards. A swath cut through vegetation is one of the best clues.

11.2.5 Weather. Obtain a forecast for the route of flight. Inquire about localized weather phenomena, such as the possibility of snow on upwind slopes or ground fog in valleys. Plan altitude routes to avoid these.

Remember that low ceiling and reduced visibility can be assets when flying in the high-threat environment. Reduced visibility is an asset because the enemy's optically and visually guided antiaircraft weapons will be less effective. The effectiveness of IR-seeking missiles will also be reduced because of the difficulty of acquiring the aircraft. A low ceiling can be an asset if friendly forces have not achieved air

superiority, as it forces enemy fighters to work in or above the cloud deck, degrading their ability to locate and attack low-flying aircraft.

A low sun angle at dawn and dusk creates large shadows in mountainous terrain that not only provide excellent en route concealment but, at the same time, create terrain hazards. That is, foothills in the shadows of larger hills or mountains may not become visible until too late. Visual threshold and depth perception are reduced and going in and out of shadows causes a visual acclimation problem.

Flying into the sun produces glare from terrain, vegetation, canopies, and visors that greatly reduces visibility. Avoid flying into the sun whenever possible. Ensure that canopies and visors are clean for all terrain flights.

Low-altitude penetration under a low ceiling becomes dangerous when sloping ceiling and rising terrain funnel you to a VMC dead-end. Patches of rain and fog can create a visual nightmare and unmasking can prove to be hazardous.

Recognition of these problems must occur early enough to circumnavigate not only the weather but also known threats.

11.2.6 Route Plotting. When the initial planning has been completed, the aircrew is ready to plot the primary and alternate routes. Alternate routes are planned in the event of bad weather, unexpected enemy activity, or other adverse conditions on the primary route. Take the following considerations into account during route plotting:

1. The course should be varied as necessary to remain masked. When crossing a ridgeline, cross at the lowest saddle. Cross open areas at the narrowest point and at reduced altitude. If paralleling a vegetated area, fly close aboard.

2. Do not fly into a situation where there is no room to maneuver if attacked. If flying near a known area defense weapon, avoid flying directly toward or away from it.

3. Plan the route with turn radius in mind. Turns should be limited to a maximum 45° bank since g reduces the visual acuity so essential for terrain flying.

4. Talk through the route with the other aircrewman. This will familiarize the crew with the terrain and ensure that terminology for specific terrain feature is understood. Standardized terms will help prevent misinterpretation and reduce unnecessary cockpit conversation.

11.2.7 Crew Responsibilities. Terrain flying is a demanding activity that requires precise aircrew teamwork and coordination, particularly with respect to flight duties and cockpit coordination. A two-man crew is mandatory for night low-level and all contour flying missions.

Specific cockpit duty assignments and responsibilities may vary depending on the mission, the tactical situation, and the terrain-flying technique employed. Since contour and night terrain flying are most demanding, the following guidelines are provided to assist in defining aircrew duties and responsibilities for these operations.

1. The pilot's primary responsibility is to control the aircraft and to avoid obstacles. He must keep his vision outside the aircraft and avoid distractions that could hinder his scan pattern. He also reports terrain and landmark information to the observer to assist in navigation.

2. The observer is primarily responsible for accurate navigation. He must remain oriented at all times and inform the pilot of course and airspeed adjustments and upcoming checkpoints. He assists the pilot by monitoring cockpit instruments and by tuning the VHF radio.

11.2.8 Contingency Planning. The three contingencies that must be specifically planned for are: air or ground attack, aircraft emergencies including birdstrikes, and inadvertent IMC. For air combat tactics, refer to Chapter 7.

In event of an aircraft emergency, each crewmember must know exactly what is required of him. The pilot shall take the immediate action required. The observer will normally read checklist procedures and make emergency radio transmissions.

Because of the altitudes encountered in terrain flying, birdstrikes are a possibility for which procedures must be briefed. The briefing should cover the possibility of aircraft control problems, engine problems, and pilot incapacitation because of birdstrikes.

If inadvertent entry into instrument conditions is made and terrain clearance is available, climb and execute a 180° turn. When unsure of clearance to the left or right, begin an immediate climb to an altitude at least 500 feet above the highest obstacle within 2,000

meters of the planned course. Upon reaching a safe altitude, initiate a 180° turn and return to VMC or request an appropriate clearance. Whenever radar-controlled air-defense weapons make these procedures unfeasible, an early decision to abort for weather must be made. The aircrew must preplan abort routes in this case.

11.3 MISSION EXECUTION

The main elements required for satisfactory execution of a well-planned terrain flight are proper visual search techniques by both crewmembers, proper navigational techniques and considerations, and proper passing of navigational information between the pilot and aerial observer.

11.3.1 Visual Search. Visual search is a technique that allows prompt and accurate checkpoint recognition. It is accomplished by both the center and peripheral fields of vision, but the peripheral field of vision plays the decisive role. To conduct visual search, the individual must first have some concept of what he will see. Checkpoints must be thoroughly characterized before the mission. Map interpretation at terrain flight altitudes requires imagination and practice because the flat visual angle distorts shape. Vertical relief is generally the most suitable means of identifying checkpoints. The aviator must also have a definite understanding of the effects of surrounding terrain, light, and seasonal change on the appearance of the objective. A 4-hour change in time of day or a 10°change in heading can significantly alter the appearance of a checkpoint. When low visibility makes visual search techniques ineffective, increase altitude (threat permitting) or decrease airspeed to provide adequate time to avoid obstacles and identify checkpoints. Visual search should alternate between a far scan for orientation and route selection, and a near scan for obstacle avoidance. Physically nodding the head up and down, rather than just shifting the eyes, provides best peripheral vision while varying the distance of the scan.

11.3.2 Navigation. Navigation becomes extremely difficult below 300 feet AGL. *Simulated* low-altitude penetration at 500 to 1,500 feet AGL has traditionally trained aircrews with a false sense of security concerning low-altitude navigation. Below 300 feet AGL, terrain features without vertical development, no matter how distinctive from above, are unusable for navigation. Thus, the selection and use of landmarks is critical to the effectiveness of pilotage and dead reckoning, and the success of target acquisition is greatly influenced by the availability of prominent terrain features easily differentiated from their surroundings.

Natural terrain features are preferable to manmade topographical features because they are more lasting in nature and less likely to be defended. Practical experience indicates that many manmade features depicted on navigation charts no longer exist or are less distinguishable than their artificial depiction. Often manmade features that do exist are not portrayed on the navigation chart. This serves to create navigational confusion and error in flight.

Low-altitude navigation ideally requires landmarks with good vertical development. For example, at 100 feet AGL you cannot see a prominent lake or treeline on the other side of a 150-foot ridgeline. Vertically developed terrain features are incorporated into a concept of horizon navigation. Prominent features on the horizon provide a much clearer and usable reference. However, each part of the world is characterized by different topographical landmarks: treelines and forest in Germany, mountains and ridgeline in the Southwest United States, and jungles in southern Asia. In each case an outsider, at first glance, would consider the trees, the mountains, or the jungles to *all look the same*. Practical experience has shown, with proper preflight planning and practice, prominent landmarks can be selected during mission planning and differentiated from similar features in flight.

11.3.3 Navigational Chart. Don't fly the black line! Employ a technique that will allow you to follow the lines of least resistance and maximize masking. Fly through rugged terrain, up against the base of mountains. Fly 5 to 10 knots over your preplanned airspeed to compensate for these deviations. At each turn point, check timing and adjust your airspeed as though you were flying the black line.

11.3.4 Navigation Information. The following guidelines will assist the observer in providing the pilot with usable navigation information.

1. Guidance information should be provided to the pilot in small increments. Generally, it need not be provided beyond the next turning point (where the route makes a major change in direction). Several terrain features should be used to identify a turning point to prevent confusion.

2. When possible, the pilot should be told to follow an identifiable terrain feature such as a stream bed or spur. If this is not available, use the clock position or instructions such as, "turn left, stop turn."

3. Tell the pilot to increase or decrease airspeed rather than to maintain a specific airspeed, since that requires him to look inside the cockpit.

Note

> The NAO/SAC(A) shall notify the pilot immediately of any warning or caution lights or if torque exceeds limits. He should never assume the pilot has seen the indication. During low-level portions of the flight, remind the pilot periodically to check fuel, engine instruments, and ammeter readings.

11.4 DETECTION AVOIDANCE

The enemy employs a variety of means by which he can detect your presence at low altitude. Some of these means are: a wide array of radar, optic, passive electromagnetic detection devices, visual sighting, and sound. By avoiding lines of communication, population centers, and industrial areas, you will greatly cut down visual sighting and noise detection. Radar, optics, and electromagnetic detection devices, however, cover much larger areas and their main function is hostile aircraft detection. Low-altitude terrain features provide opportunities for both direct masking (breaking line of sight with the threat radar, i.e., flying behind a mountain, ridgeline, or rock) and indirect masking (radar interference from ground clutter, i.e., flying close enough to reflective terrain that both your aircraft and the terrain are within the resolution cell of the threat radar). These masking techniques may severely degrade or eliminate radar detection. Maximize optical masking by flying over dark rugged terrain, in mountain shadows, or use indirect terrain masking against backgrounds that will allow your aircraft to blend in. Painting the aircraft to blend into the terrain over which you will fly will aid greatly. Minimize electromagnetic emissions by turning off emitters (radar altimeter and IFF) and execute the mission mincom.

11.5 LAT TRAINING

To expect aircrews to enter a combat arena at low altitude without proper preparation would simply be spending aircrews and machines needlessly. Specific LAT skills should become habit patterns. The ability to recognize, prioritize, and react properly to relevant combat contingencies in flight should become second nature, especially in a low-altitude regime.

As LAT training begins, two specific altitudes are referred to. The first is that altitude at which *all* assigned aircrew responsibilities can be comfortably performed, to include defensive reactions requiring intensive maneuvering. This altitude is known as comfort level (CL). The *minimum* comfort level altitudes for all Marine Corps aircraft are found in the Training and Readiness Volume I. The altitude below comfort level at which maneuvering is severely restricted, performance of aircrew responsibilities are degraded, and maintaining a very low altitude in the primary defense is known as minimum altitude capability (MAC). As outlined in the Training and Readiness Volume I, MAC is not applicable for the OV-10. The achievement of an OV-10 crew's tactical comfort level is directly related to aircrew training, proficiency, and currency in the low-altitude regime.

11.6 FLIGHT TECHNIQUES

The key to an effective low-altitude flight training program is a progressive program. This program must begin at an intermediate altitude and allow the individual aircrewman to progress at his own rate until he is eventually able to perform all required maneuvering and aircrew responsibilities at an altitude that will effectively degrade the enemy defense system. The following text covers some suggested techniques of the more difficult low-altitude maneuvers. The first is the 2g to 4g level turn and the second is ridgeline crossing.

11.6.1 Level Turns

11.6.1.1 Roll-In. Prior to commencing a turn, check for a visual reference 90° to the flightpath. This will preclude the distraction of checking the compass, and the reference can be used for flightpath or course resumption. The roll-in should be a rapid, unloaded roll to a bank angle which will allow the nose to track a straight line along the horizon. Obviously, you don't know what the bank angle will be until you are established in the turn and can identify trends in nose position. (A rough gauge would be 70° to 80° angle of bank depending upon g-loading). Once the angle of bank is established, the required back stick should be positively applied to prevent the nose from falling through and requiring an immediate correction.

11.6.1.2 Establishing the Turn. In order to monitor trends in nose position, the eyes should be oriented on the ground at left 10 o'clock (for a left turn) so that peripheral vision includes the nose of the aircraft at one extreme and a view of the terrain being turned into on the other. As the turn progresses, this perspective allows constant cross-check of proximity to the ground vs. any tendency the nose has to rise or fall. Corrections should be made by adjusting bank angle. If a climbing trend is evident, do not attempt to overbank down to the original altitude. Arrest the climb by reducing g and increase bank angle. Then complete the turn at the present altitude and descend to the desired altitude after returning

to level flight. Use of rudders is not recommended once the turn is established since your inputs will disturb your interpretation of nose position.

11.6.1.3 Rollout. Just prior to rollout make a final check of the nose position. If it is slightly below the level reference, roll out with slight back stick pressure to break the descent. During rollout, the eyes should shift to focus attention directly over the nose. This will allow an immediate correction of any tendency to climb or descend.

11.6.2 Terrain Flight. Although flat terrain is ideal for training purposes, many low-altitude flights do not occur, nor should they occur, over flat unobstructed terrain. Rough, rolling, or mountainous terrain should be utilized as an aid to mission accomplishment, not as a hindrance. Even though rough terrain, by itself, affords some built-in protection, our job is to know how to use this terrain to minimize telltale exposure. Occasionally, no matter how hard we plan, there will come a time when circumnavigation of high terrain may be impossible and a ridgeline will need to be crossed. It is acknowledged that some exposure will occur as the aircraft crosses the peak. In most situations, we would like to minimize our exposure, not only on both sides of the ridge to be crossed but also as our aircraft passes over the summit. The techniques discussed herein are in terms of crossing a ridgeline, but are equally applicable to hilly or mountainous terrain.

11.6.2.1 Ridgeline Crossing Techniques. The most common technique used in low-altitude ridgeline crossing is "the high speed in the weeds" approach with no thought being given to what will happen at the summit or on the far side of the ridgeline (Figure 11-1). The nearside contour is followed as closely as possible and the airspeed is pushed up to something approaching OV-10 Mach followed by a last second climb angle and an upward trajectory at the summit. At this point comes the realization that no amount of g will alter this predetermined path toward the moon. The aircraft is highlighted at the summit, elements of direct and indirect terrain masking having long since vanished, and tactical surprise is lost. The USAF has appropriately dubbed this technique *The Ivan thanks you very much maneuver*.

11.6.2.2 90° Angle of Technique. A more logical approach to the problem would be to start the maneuver by sacrificing a little exposure on the near side of the ridgeline. Pull up early to create a shallower climb angle and apex at the minimum possible altitude in an attitude of level to slightly nosedown (Figure 11-2). At the summit analyze the relief gradient on the back side. Usually you can fly the contour easily and effectively with a bunt maneuver. In a few cases, however, the terrain may drop off significantly as a slice turn or 135° pull down would make a more g comfortable maneuver, while maintaining better indirect terrain masking. If a heading change is desired, either for course or lookout considerations, perform the turn in conjunction with the maneuver to regain terrain masking. Terrain on the far side of the ridgeline will determine the exact technique to be used. However, two suggested techniques are the 90° angle-of-bank and the 135° angle-of-bank pulldown.

If the terrain on the far side of the ridgeline is unknown, flat, or gradually sloping the 90° angle-of-bank technique will afford both a desired g-loaded turn and a controlled nose attitude to conform to the slope gradiant. The technique is to roll into a 90° angle of bank turn as the summit is crossed and use slight increase or decrease in the angle-of-bank to achieve the desired nose attitude. In cases where the terrain slopes appreciably, the 135° angle-of-bank pulldown should produce both the desired heading change and an expedient resumption of terrain masking. At the summit, roll into a 135° angle-of-bank turn and use desired g-loading to commence the turn, simultaneously pulling the nose down to the horizon. As the nose passes through the horizon, complete the turn by reducing the angle of bank to that required by g-loading to maintain the nose at the appropriate altitude.

11.6.2.3 45° Angle-Off Technique. In cases where navigational timing, distance, and heading will allow deviations, or a threat in the stern quarter requires maintaining both terrain masking and a minimum altitude, a 45° angle-off approach can be used (Figure 11-3). This will provide the required masking as well as the ability to maintain a minimum altitude throughout the maneuver. With this method the aircraft remains at low altitude while approaching the ridgeline. Nearing the base of the ridgeline a turn is accomplished to place the aircraft's approaching angle at approximately 45° with respect to the ridgeline. The aircraft is then flown up the side of the ridge at low altitude but with a much shallower climb angle than would be required to cross the ridge at a 90° crossing angle. Nearing the crest of the ridge, a level turn is performed until crossing the summit. At this point, the ridge's far side relief gradient is analyzed. The appropriate maneuver is then accomplished to maintain masking as well as to perform a heading change back to the original course or to a new course if desired. Whichever technique is used, be acutely aware of your energy state and turning room required for maneuvering.

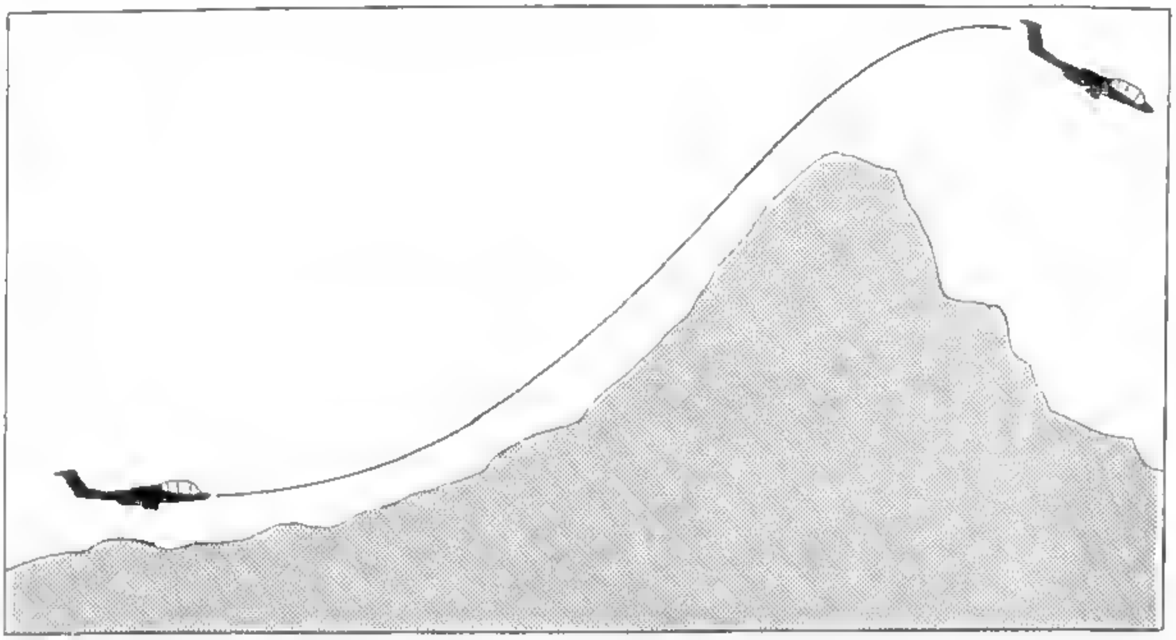


Figure 11-1. 90° Ridgeline Crossing (Incorrect)

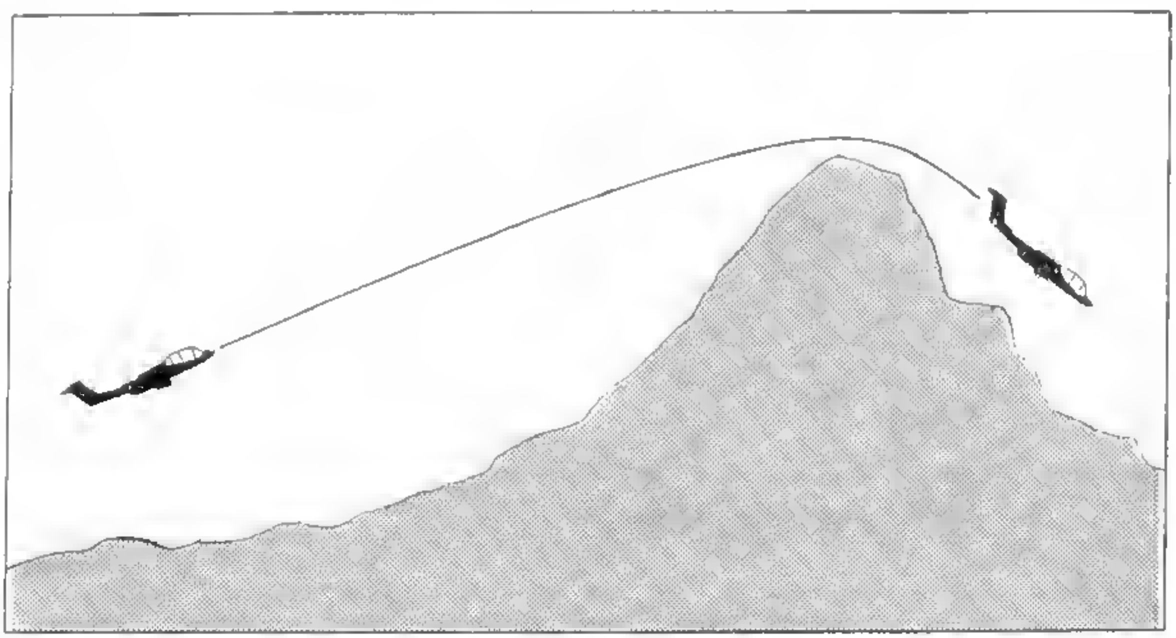


Figure 11-2. 90° Ridgeline Crossing (Correct)

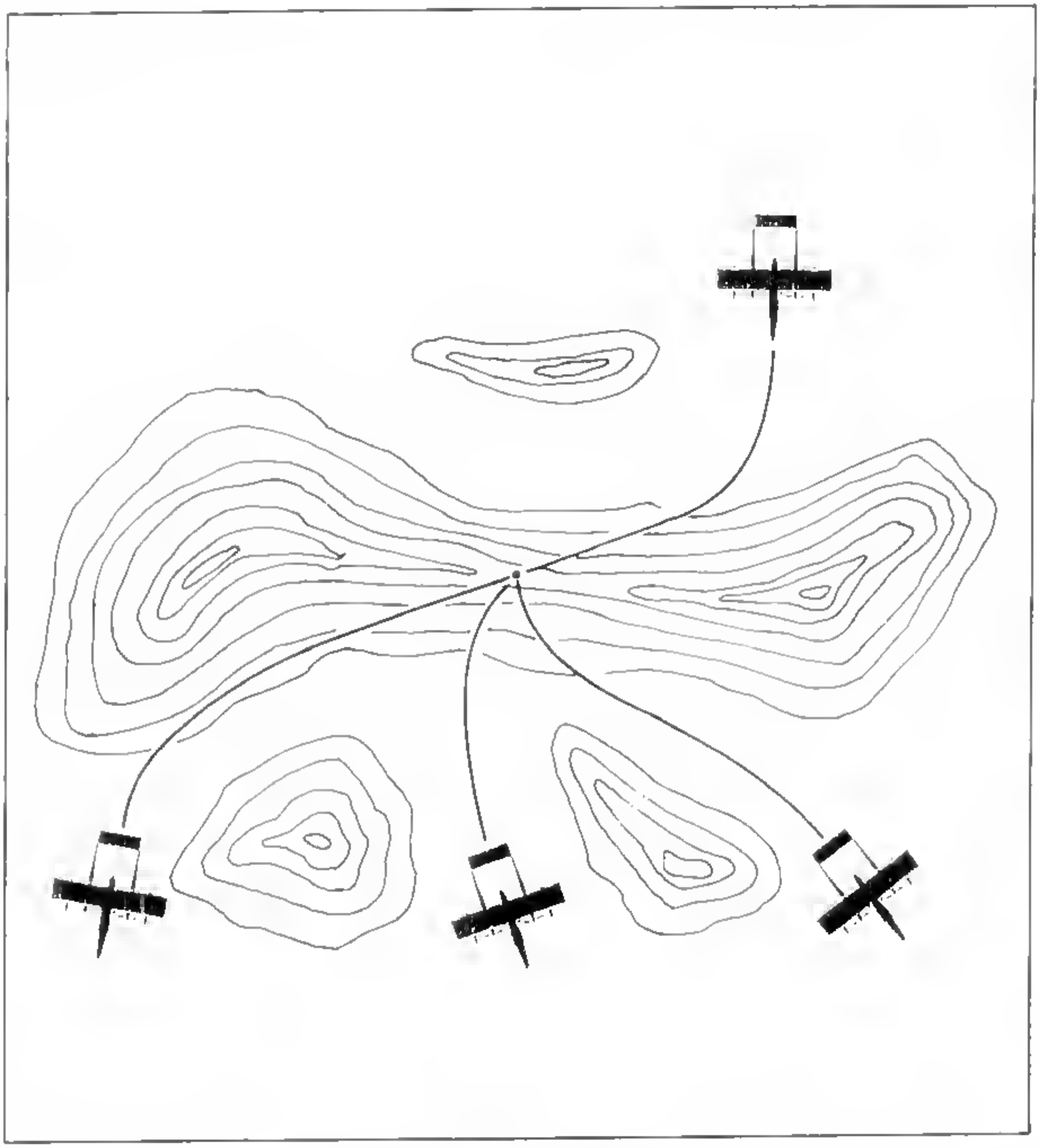


Figure 11-3. 45° Ridgeline Crossing

11.7 MOUNTAIN AND ROUGH TERRAIN FLYING

Many missions require flight in rough and mountainous terrain. Refined flying techniques, along with complete and precise knowledge of the associated problems to be encountered, are required. Wind direction and velocity, gross weight limitations, and effects of obstacles are a few of the considerations for each operation. The effects of mountains and vegetation can greatly vary wind conditions and temperatures. Altitude and temperature are major factors in OV-10 power performance. Gross weight limitations under specific conditions can be computed from the performance data in the NATOPS.

11.7.1 Effects of High Altitude. Engine power available at altitude is less and climbing ability can be limited. High gross weight at altitude increases power required. A permissible maneuver at sea level must be tempered at higher altitude. Smooth and timely control application and anticipation of power requirements will do more than anything else to improve high-altitude performance.

11.7.2 Turbulent Air Flight Techniques. Aircrew must be constantly alert to evaluate and avoid areas of sever turbulence, however, if encountered, immediate steps must be taken to avoid continued flight through it. Severe turbulence is often found in thunderstorms, and bronco operations should not be conducted in their vicinity. The frequently encountered type of turbulence is orographic turbulence. It can be dangerous, if severe, and is normally associated with updrafts and downdrafts. It is created by moving air being lifted by natural or manmade obstructions. It is most prevalent in mountainous regions and is always present in mountains if there is surface wind. Orographic turbulence is directly proportional to the wind velocity. It is found on the upwind side of slopes and ridges near the tops and extending down the downwind slope. It will always be found on the tops of ridges associated with updraft on the upwind side. Its extent on the downwind slope depends on the strength of the wind and the steepness of the slope. When the wind blows across a narrow canyon or gorge, it will often veer down into the canyon. Turbulence will be found near the middle and downwind side of the canyon or gorge. The procedure for transiting a mountain pass shall be to fly close abeam that side of the pass of canyon that affords an upslope wind. This procedure not only provides additional lift, but also provides a readily available means of exit in case of emergency. Maximum turning space is available and a turn into the wind is also a turn to lower terrain. The often used procedure of flying through the middle of a pass to avoid mountains invites disaster. This is frequently the area of greatest turbulence and in case of emergency, the pilot has little or no opportunity to turn back because of insufficient turning space.

CHAPTER 12

Thermal Imaging and Lasers

12.1 INTRODUCTION

The OV-10D night observation surveillance system (NOS) consists of a thermal imager called the forward looking infrared (FLIR) sensor and the laser ranger/designator (LRD). This system provides a unique day and night operational capability to perform a wide variety of air-to-air and air-to-ground support missions.

12.2 BASIC INFRARED THEORY

The employment of a thermal imager is based on a very simple, but fundamental principal: heated objects tend to emit infrared (IF) energy through vibration, known as radiation, or thermal radiance (Figure 12-1). IR energy comprises that part of the electromagnetic spectrum between the visible waves and the radio waves (Figure 12-2). The magnitude of the thermal radiance emitted by an object is determined by several factors. Included in these factors are the object's temperature, its surface reflectivity and its structural properties. Natural IR energy is produced when objects absorb and radiate solar energy and convective heat energy from warm air currents. Manmade energy, especially in vehicles, results from fuel combustion heat generated by engines and frictional heat generated by moving parts. These last two sources cause operational target vehicles to emit large amounts of IR energy. These thermal sources acting upon objects in the operating environment produce the radiant energy that makes up a thermal scene.

The FLIR utilize a germanium lens to focus the IR energy through a number of different components which focuses the energy onto detectors that convert the energy to electrical energy. The electrical energy is amplified and used to drive small visible picture elements called light emitting diodes (LEDs) or is sent to a cathode ray tube (CRT), which is similar to a TV picture tube. Thus, IR energy is ultimately converted into visible light (Figure 12-3)

12.2.1 Thermal Scene Variables. Visual discrimination of objects in the thermal scene is made possible by the fact that most of the objects have a radiated temperature either higher or lower than their immediate backgrounds. Even if the radiated temperature differences are less than a degree, they may appear on the display of a thermal imager. The temperature differences appear as variations of brightness of the objects on the FLIR display. The concept of temperature difference, called "DELTA T" (ΔT), is fundamental to thermal imagers. If there is no difference ($\Delta T=0$) between the radiated temperature of an object and its background, the object will not be distinguishable from its background. It will, in effect, be invisible. Usually, targets have a positive contrast at night (i.e., the object is warmer than the background) and a negative contrast (i.e., the object is cooler than the background) on sunny days. The thermodynamics of the battlefield background can be confusing and cause problems with target recognition. Many of the natural and manmade objects on a typical battlefield undergo continual temperature changes that follow important predictable trends. For example, natural background objects such as trees, grass, rocks, and earth, are heated passively through the absorption of solar energy. Even during overcast days, some solar radiation is absorbed. Daily solar heating begins at sunrise. After midday, the sun declines and the background objects begin to cool. After sunset, the objects cool down to approach the temperature of the surrounding air. The daily, two-part heating and cooling cycle is called the *Diurnal Cycle* (Figure 12-4). Thus, an IR background is thermally dynamic.

During the diurnal cycle, individual background and target objects heat and cool at different rates. Large, dense, or heavy objects, such as medium-sized rocks, tree trunks, and nonoperating armored targets, heat and cool slowly. Heavy objects are said to have *high thermal mass.*. Lightweight objects, such as grass, tree leaves, bushes, and the surface layer of the ground itself, heat and cool quickly. Lightweight objects are said to have *low thermal mass.*

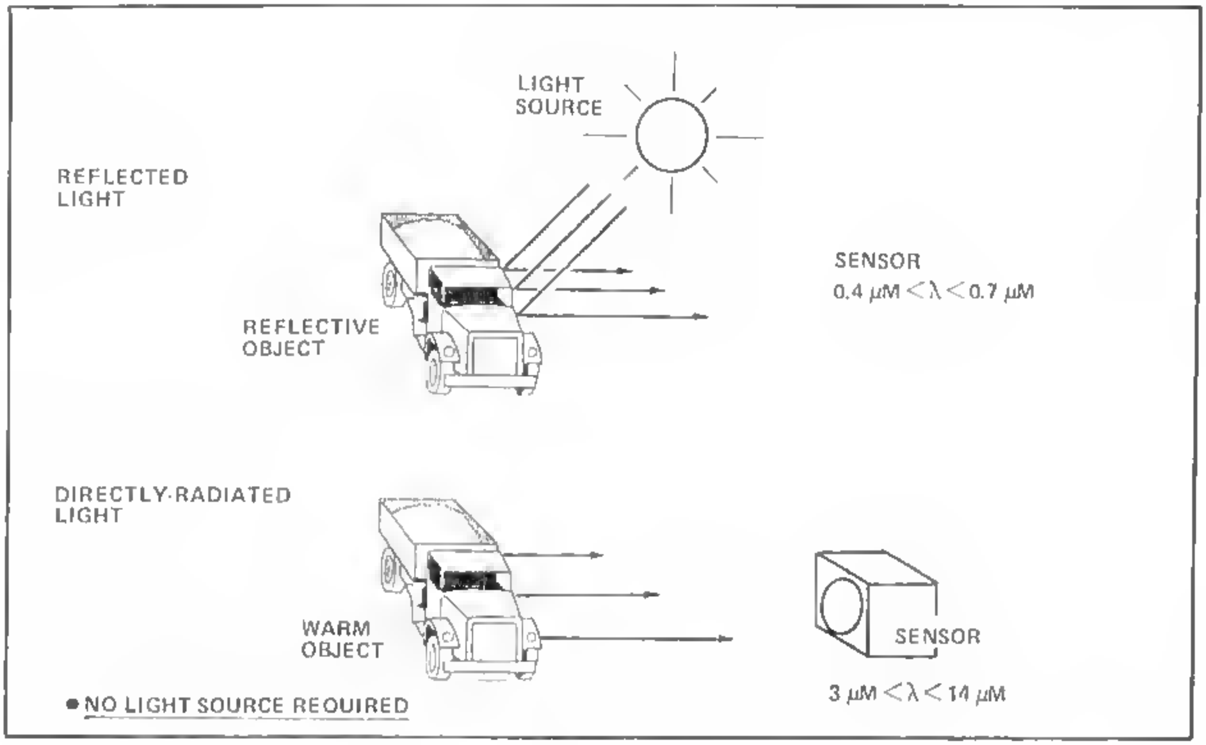


Figure 12-1. Types of Imaging

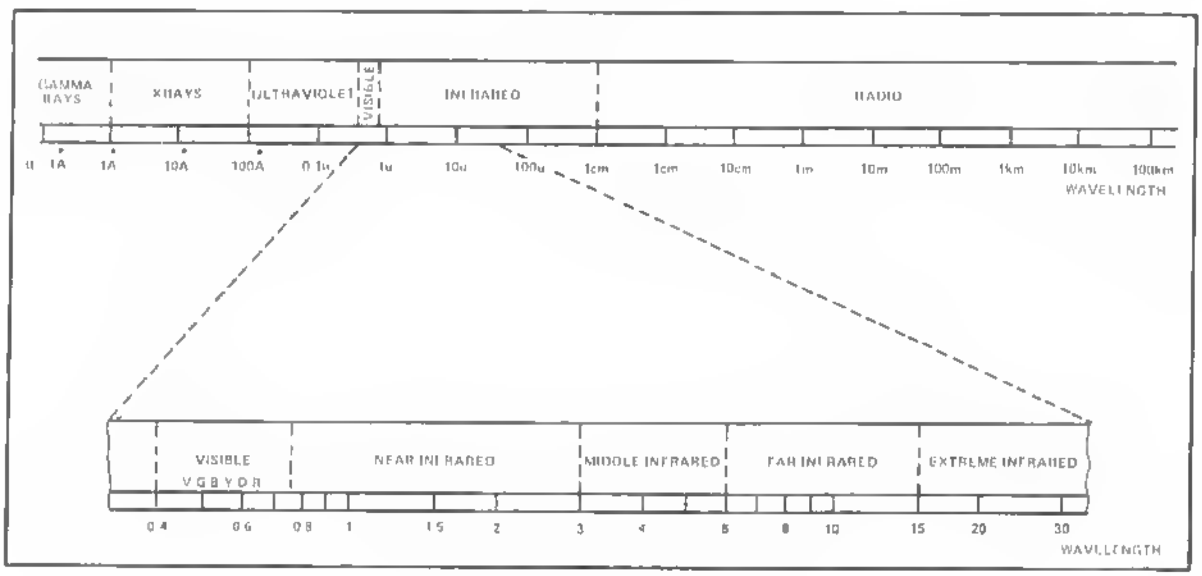


Figure 12-2. Electromagnetic Spectrum

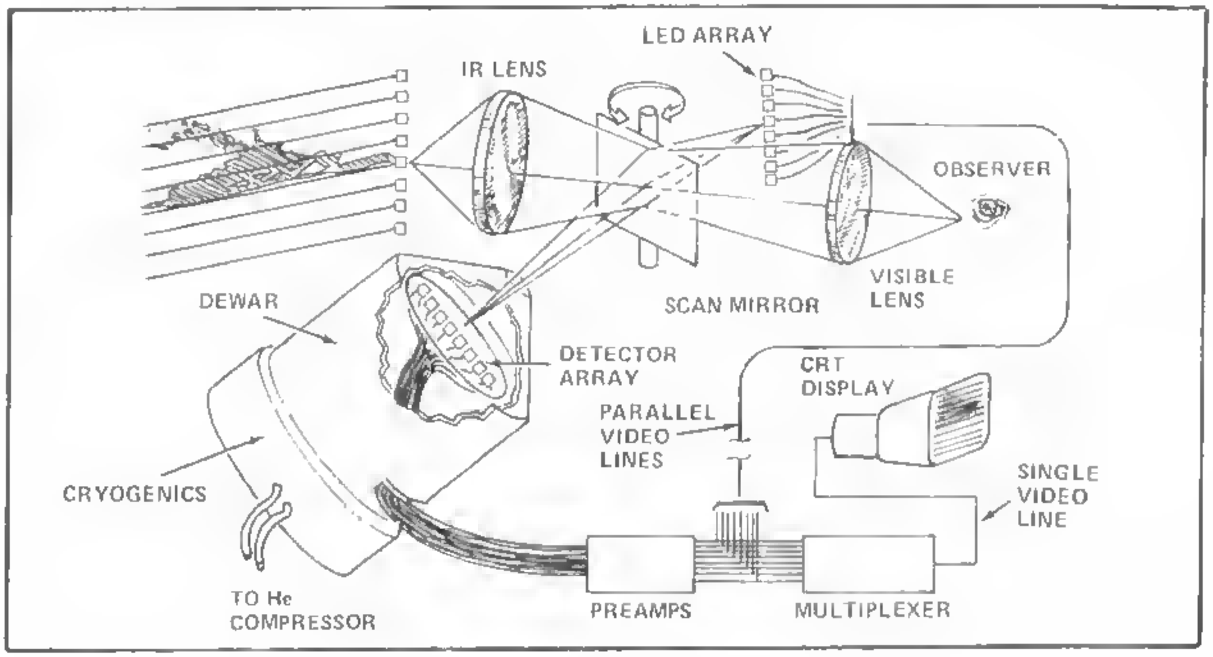


Figure 12-3. IR Sensor Operation

In sunny-day cycles, objects with high thermal mass usually do not reach nighttime background temperature before the sun rises once again to restore the heat cycle. As the sun rises, the cool background warms up rapidly to exceed the temperature of heavy objects. This point, where the background temperature passes the temperature of the heavy object, is called the diurnal *crossover* (or *thermal crossover*) point (Figure 12-4). When the morning crossover occurs, the background appears hotter than the target and a negative contrast target appears. When the afternoon crossover occurs, the target appears hotter than the background for a positive contrast target. The timing of these crossovers is greatly influenced by environmental factors. Thus, this discussion should only be thought of as a generalization of the *diurnal* and *crossover* concepts. Within the target itself, significant temperature changes occur. Consider target-type objects such as tanks, trucks, and APCs. These targets have internal temperature variations which form visible patterns that are the fundamental elements of target signature cues. With the FLIR in *white hot*, the hottest operational vehicular parts, such as the engines and exhausts, stand out as bright shapes. The medium-temperature objects, such as warm tracks and other warm parts, appear medium bright. Finally, the relatively cool hull, and other cool parts, appear dark.

Certain smooth, glossy surfaces, such as vehicular windshields and glossy painted fenders, can reflect IR radiation images impinging on them from other sources. In white hot, vehicle windshields often appear very dark because they reflect the low radiant temperatures of the cold night sky. Similarly, the fenders of a tank appear very dark due to this thermal reflectance of the cold sky. An overcast sky can cause warmer thermal reflections. The thermal radiance from a fire located next to a glossy painted APC could be reflected off the vehicle's flat side surfaces. Thermal radiation can produce some odd signature effects. The FLIR operator should be aware of this phenomenon and understand that it may be used to his advantage for target *lock-on*. Only very smooth glossy surfaces are subject to strong reflections. Generally, surface reflections are diffuse in nature and do not usually cause problems.

12.2.2 Target Appearance Variables

1. Weather — thermal signatures are highly variable. Variations in solar heat, fuel combustion heat, frictional heat, and thermal reflective affect IR signatures and IR target recognition cues. In addition, some atmospheric conditions degrade FLIR signature performance, while others can actually enhance it. All possible combinations of these factors cannot

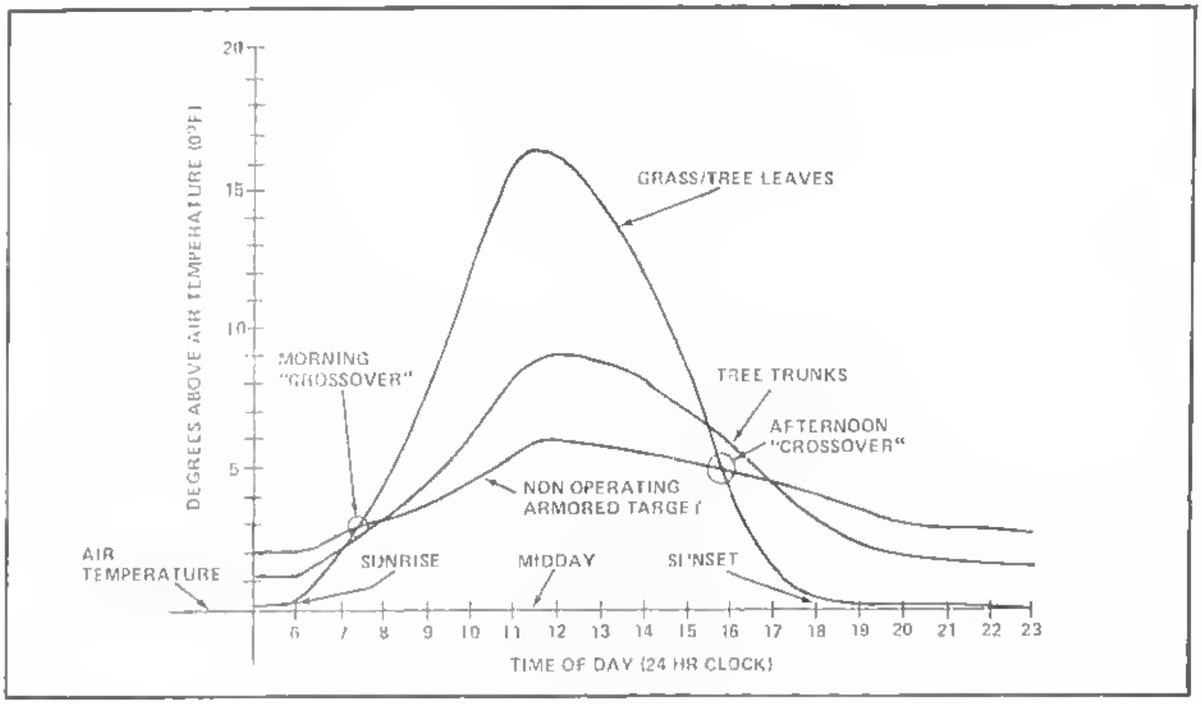


Figure 12-4. The Diurnal Cycle

be addressed here, but the general trends will be discussed.

Since IR energy does not transmit well through air filled with water droplets, precipitation (rain and snow) and fog will tend to reduce the transmission of IR energy through the air. The apparent temperatures of both target features and background objects are decreased. Fallen snow tends to make all ground temperatures the same. Depth perception by size comparison becomes very difficult with snow cover due to a lack of terrain features with which to reference size. The cool washed-out background can enhance FLIR target detection, by reducing the amount of clutter in the scene. As with precipitation affects discussed above, the targets often stand out conspicuously, especially with the engines operating.

The effects of dust particles on FLIR visibility are similar to those of falling precipitation. FLIR visibility through artillery impact dust is momentarily reduced significantly. Only the hotter objects and targets features penetrate these obscurants. However, FLIR visibility through fog, rain, snow, and dust, while severely degraded, is usually superior to normal unaided eye visibility. Thus, the FLIR is considered a relatively good penetrator of these elements. FLIR can be used effectively to supplement and extend eye visibility in daytime fog and dust. FLIR visibility through diesel fog and oil smoke is also very good. Very little atmospheric transmission loss results from these conditions.

2. Day versus night — day thermal signatures differ greatly from night signatures. This is especially true for sunny days and clear nights. It is less true for overcast or rainy days and nights. The source of the differences is primarily the solar heating effect. As noted above, solar heating generates target shape cues that persist in a helpful way into night operations. However, solar heating makes daytime IR target recognition troublesome.

Targets are heated by the sun on warm days to relatively high temperatures. The outer hull does not always heat evenly because of shadowing. IR reflections during the daytime can also provide spurious hot spots on the vehicle. Another problem in daytime recognition is the daytime contrast reversal where the background features and other objects increase screen clutter and target signature variation tremendously. This is especially troublesome from midmorning through midafternoon. The combination of shadows, reflections, and uneven heating can make daytime

FLIR target recognition very difficult and confusing. The many hot background *clutter objects* make long-range detection difficult. Figure 12-4 showed how relatively high background temperatures rise on sunny days. However, moving targets can be detected at long ranges during hot, sunny days with FLIR. Without the motion, though, many false detections should be expected. Rainy day IR signatures are more consistent with expected target cues. As the rain cools the background, the targets tend to stand out conspicuously due to their high ΔT's. Operating targets on rainy days usually exhibit positive contrast.

12.3 FLIR NAVIGATION AND RECONNAISSANCE

This section discusses planning, briefing, and execution of flights at night which involve navigation and reconnaissance in conjunction with the OV-10 FLIR system. Planning and briefing processes are discussed in Chapter 8. The flight execution paragraphs discuss FLIR navigation to an assigned area of reconnaissance and the conduct of the reconnaissance within the area.

12.3.1 Mission, Enemy, Troops, Terrain, and Time (METT-T). As with all missions, a careful analysis of METT-T factors must be accomplished. Night flights, however present difficulties in navigation, orientation, and crew coordination. The following METT-T factors discussed are in addition to those discussed in previous chapters and cover areas of difficulty unique to night flight.

12.3.1.1 Mission. A thorough examination of mission requirements must be conducted to begin planning. Items examined should include an overall situation brief, essential elements of information required by the requesting agency, the format required in those reports, any time-driven requirements, and any information reporting procedures different from those contained in SOPs or operation orders. This will require the aircrews involved to have a complete knowledge of the Marine aviation command and control system and the ground command and control system as well. Due to mission execution difficulties at night, more time than normal should be allowed for planning and a minimum of two hours allowed for mission briefing.

12.3.1.2 Enemy. Night flight does present some advantages not found in daylight. The enemy's SAM electrical optical systems are greatly degraded and if illumination is minimal, shoulder fired infrared systems will experience extreme difficulty in locating and tracking airborne targets in sights and view finders. Radar is not degraded however, and all SAM positions should be plotted and weapons weaknesses and strengths should be analyzed. Once this analysis is completed, in conjunction with an analysis of other items, a route and altitude into the target area may be selected.

12.3.1.3 Troops. In this context, this means supporting assets available to the aircrew executing the mission. Because of low-level flight difficulties at night, a great deal of consideration should be given to obtaining electronic countermeasure services. If other assets are used, timing requirements at route checkpoints and other areas which expose the aircraft to radar detection must be established. The degree of threat may also determine the number of aircraft assigned to the reconnaissance mission.

12.3.1.4 Terrain and (Weather). As usual, a thorough map study must be conducted. The terrain should be examined in conjunction with the briefed enemy air defense and shadow profiles constructed to ascertain safe routes and altitudes into and in the assigned area. As the amount of moisture in the ground has a direct effect on the degree of infrared energy reflected, care must be given to locate and plot all such items and if necessary use these bodies of water (streams, lakes, large ponds, rivers) to aid in navigation. A comparison of 1:250,000 and 1:50,000 scale maps must be made and any features found on one but not on the other such as power lines, towers, and roads must be transposed to the map lacking those features. Checkpoints along the route and inside search area should be selected as an aid in navigation. These may include large prominent terrain or cultural features. Since flight at higher altitudes presents exposure to enemy radar, flight over high terrain should be avoided, instead, these prominent terrain features can be used as funnelling aids to ensure the aircraft remains on the desired ground track. Other items which may aid in navigation are railroads, rivers, roads, highways, and canals. If these items are used and flight is parallel to these lines of communications, extreme care must be given to the briefed enemy threat to ensure avoidance of enemy air defenses. If illumination permits, the aircrew should use night vision goggles to aid in navigation and search as a complement to the FLIR. Towns, villages and power lines should not be selected if possible as a FLIR navigation aid as they give poor representation on the FLIR screen. Bad weather such as isolated rainstorms, and low overcast skies which may prove beneficial to flight under combat conditions will increase the hazards at night and should receive special consideration. Unfavorable weather conditions such as rain, duststorms, and snow will also degrade the effectiveness of the FLIR.

12.3.1.5 Time Available. As in all missions, sufficient time must be allowed for mission planning. Be sure to evaluate the amount of time needed to accomplish the mission. Extra transit time must be allowed due to the unique difficulties of operating at night.

12.3.2 Briefing. As usual, the tactical and NATOPS briefing guides should be used to conduct the brief. It is imperative that the briefer use maps and diagrams to inform all participating members of the entire route and search patterns planned within the assigned area. Routes and patterns should be marked on the maps and diagrams in thick black lines with prominent headings, times, and distances also displayed in a like manner for each leg in the flight. This will enable the route and search pattern to be easily followed during flight. Prominent terrain and cultural features used during the flight should be noted and discussed, particularly as to their expected appearance on the FLIR screen. Although only one flashlight is required during night flight, both crewmembers should carry one. The air observers should be fitted with a diffused white lens to allow better visibility of the map and forms used. This should not increase the glare already present from the CRT. All maps should be folded at this time to show only the areas of interest and after briefing should be placed in map bags in order of desired usage. Kneeboard cards constructed and distributed should contain wide black markings for easier visibility during flight.

12.3.3 Navigation to Assigned Area. Immediately upon launch, the aircraft should proceed to a point outside the traffic control area that can be identified without the use of NVGs or the FLIR. This will allow the crewmembers to become established upon course with a readily identifiable initial point and consequently avoid time lost by having to immediately begin the FLIR search to become established on course. Once established at the initial point, the FLIR should be examined to determine the correct mode of heat (white or black) which will give the best contrast. Voice annotation of the FLIR should be conducted; the minimum items voice recorded should include the date-time group of commencement of the tape, names of aircrews, coordinates of starting point, initial aircraft heading, mode of heat contrast, aircraft altitude and speed, mission number assigned and destination. At each change in aircraft altitude, heading, or other significant changes during navigation, the voice annotation should be updated. Under combat conditions, aircraft lights should be turned off at this point.

12.3.3.1 Altitude. Although altitude flown during the flight must be consistent with the briefed threat, night navigation can be readily accomplished from 1,500 to 2,500 AGL.

12.3.3.2 FLIR Angles. During navigation, the FLIR should be angled down no more than 15° and to the left or right no more than 20°. This restriction coupled with wide field of view should be adequate for navigation and will allow pilot and air observer to remain oriented.

12.3.3.3 Course Changes. The route should be planned to keep course changes to less than 60° if possible to maintain orientation. A technique to effect course changes is to identify the upcoming checkpoint in the FLIR, restate the new heading (ensuring voice annotation of the tape) and as the aircraft approaches within one-half mile of the turn point, slowly slew the FLIR to the new heading (staying within the 20° restriction); keep the FLIR slewed in that direction until the FLIR courser coincides with the new direction and then bring the FLIR courser back to zero as the aircraft steadies on the new heading. Once established on the new heading, slew the FLIR 20° left and right to confirm expected terrain and cultural features. This process should be continued throughout the flight (along with voice annotation of the tape). If misoriented, the aircraft should return to the last known point to regain course vice beginning a search to locate the next expected checkpoint. Aircrews should both have appropriate maps folded and readily visible. One technique to remain oriented is to keep a thumb on each checkpoint reached in succession.

12.3.3.4 Terrain and Checkpoint Crossing. Because of the difficulties of crossing terrain with significant vertical definition at night while attempting to avoid radar detection, the route should be planned to avoid such crossings to the maximum extent possible. These significant vertical features may still be used as navigational aids but the route should be planned to skirt the edges of such features. If high terrain must be crossed, it should be approached at an angle to allow constant orientation before the actual crossing. This will allow the aircraft to climb to an altitude slightly below the terrain elevation and retain sufficient energy to expeditiously effect the crossing and rapidly resume normal route altitude.

12.3.4 Reconnaissance. The same principles that apply during daylight reconnaissance and search missions are consistent with night operations regarding intelligence reporting, delineation of the area to be reconnoitered on maps, assignment of priorities to areas to be searched in succession and maintenance of a chronological log of all events and sightings to aid in debriefing.

12.3.4.1 Voice Annotation. The voice annotation of the videotape may serve as the record of the flight for this type mission. The items previously discussed should be annotated at the first leg flown of the reconnoitered area and should be updated for each sighting and flight change.

12.3.4.2 Search Altitude. Normally, an area or route reconnaissance flight whose goal is terrain intelligence may be flown at 500 to 1,000 feet AGL. If such a flight is conducted, the wide field of view will be sufficient for intelligence requirements. The narrow field of view may be used for close-up views of items of particular importance, such as bridges, sharp bends in roads, culverts, intersections, and so forth. This altitude is also consistent when searching for large formations of personnel or vehicles. If time and threat permit, route and area reconnaissance should be flown twice, once at wide view and again at narrow view. When searching for small groups or personnel, single vehicles, or small camouflaged fortifications, the search altitude may have to be lowered to 200 feet AGL during combat conditions. Terrain orientation with maps on board remain a must throughout this type flight to enhance plotting of targets.

12.3.4.3 Crew Coordination. The aircrew must work closely together to conduct such a reconnaissance mission, constantly confirming headings, altitudes, locations, and angle off the nose of the FLIR. The pilot, if illumination permits, may use NVGs to locate an object not easily detected by the FLIR and may give angles off the aircraft nose along with a ground reference (i.e.; at base of hill) to aid in directing the FLIR onto the target. If this does not succeed rapidly, he may place the FLIR under his command and point the nose of the aircraft to the target before relinquishing command back to the rear crewmember. Once a target is located and time and threat permit further observation, both heat modes should be used to examine the target in conjunction with wide and narrow fields of view. During this observation, the pilot may fly a circular pattern or lazy eights to maintain the target in FLIR view. A less than normal use of ailerons and more than normal use of rudders should be used to effect such turns to keep the target in view. If using lazy eight flight patterns, all turns should be toward the target from the aircraft nose. If target coordinates are not readily determined the location may be given by voice annotation on the videotape by giving the target location in reference to a terrain feature. Another method of target locations is to establish several easily identifiable control points within the search area. Assuming orientations is maintained in relation to the selected control points, the crew could take a heading and using the laser ranging mode obtain azimuth and distance to the target and therefore target location. Primary responsibility for functions should be established before flight for communications, target identification, and navigation. Both crewmembers may be able to participate in navigation en route to the search area, but once in the area, a greater than normal burden will be placed on the pilot to maintain orientation due to the rear cockpit's efforts at target observation on the FLIR.

12.3.5 Physiology. Refer to Chapter 18, Night Vision and Night Vision Goggles (NVGs), of this manual. Much of the information concerning the physiological factors of night vision, visual illusions, spatial orientation, and terrain interpretation for NVG operations are applicable to FLIR operations.

12.4 NIGHT ARTILLERY ADJUSTMENT

The FLIR can be used to passively view a scene while adjusting artillery on a target within the scene. By locating the target in relation to prominent terrain features on the screen, a target grid location can be determined. Once the adjusting round impacts, and using the gun target line for direction, the target can be engaged without any outside source of illumination. The primary advantages of this technique are the ability to stand off and adjust artillery while using a passive observation system, the ability of FLIR to detect targets in spite of camouflage efforts, and the ability of the aircraft to use mobility and optimum communications with the adjusting battery.

12.5 LASERS

The proliferation of lasers on the battlefield, whether used as range finders, designators, flashblinders, or designated weaponry, poses a significant optical/electro-optical threat to our night operations. Our reliance on high technology night systems that are very sensitive to very low levels of reflected visible or near IR light is jeopardized by a weapon that can direct light and heat against us. Use of the FLIR is also threatened by the introduction of directed energy weapons. Meeting the demands of hardening our night systems and protecting our aircrews with appropriate tactical countermeasures begins with a thorough understanding of the laser, its strengths and limitations, and the depth of its potential threat.

12.5.1 Defining Laser. The laser is an electro-optical device which produces ultraviolet, visible, or IR radiation by the process of controlled stimulated emission. The acronym LASER stands for light amplification by stimulated emission of radiation. Lasers generate a *collimated*

beam (i.e., parallel rays) of intense, *coherent* (i.e., the photons are in-phase), monochromatic light which is within the radiation portion of the electromagnetic spectrum. The emitted beam can be either continuous wave (CW) or pulsed. A pulsed laser is usually more powerful and damaging than a CW, because the energy is condensed into rapid, bullet-like pulses. These pulses commonly last about 20 nanoseconds.

The wavelength of energy emitted is determined by the material being lased (e.g., Ruby, Neodymium YAG, etc.) which in turn determines its application, its effectiveness as a threat, and the protection required to counter its effects. Figure 12-5 shows the spectral location of the sensors we use at night, and the laser lines that pose an in-band threat to those sensors. Those lasers that emit in the same spectral region as the sensitivity of the sensor are in-band to the sensor, and require very little power or exposure duration to produce effects. Those lasers outside the sensitivity of the sensor are out-of-band, and usually require more power, or longer periods of exposure, to adversely affect the sensor.

12.5.2 Lasers and Night Vision. The human eye is sensitive to the visible wavelengths between 0.40 and 0.75 microns. Common lasers within this band include the continuous wave green Argon (0.511 microns), the pulsed green Doubled Neodymium (0.532 microns), and the pulsed red ruby (0.694 microns). The Argon, since it is a continuous wave laser, will most likely produce retinal damage. Out-of-band lasers are absorbed by the front structures of the eye, and are therefore functionally invisible. Near IR lasers are an exception, in that they are transmitted to the retina, but are still invisible. Out-of-band lasers with sufficient power can produce thermal injuries.

Laser eye protection must be specifically designed for the threat wavelength, and must have high scotopic transmitivity; that is, sufficient light must be able to pass through the protection to allow safe flight operations.

12.5.3 Lasers and FLIR. The only in-band laser in the 8 to 12 micron IR region is the CO_2 laser, which operates at 10.6 microns. Nevertheless, a CO_2 laser will produce saturation of the thermal detector with very little energy. As the energy is increased, the detectors may be damaged and rendered useless. Attempts at FLIR hardening are on-going.

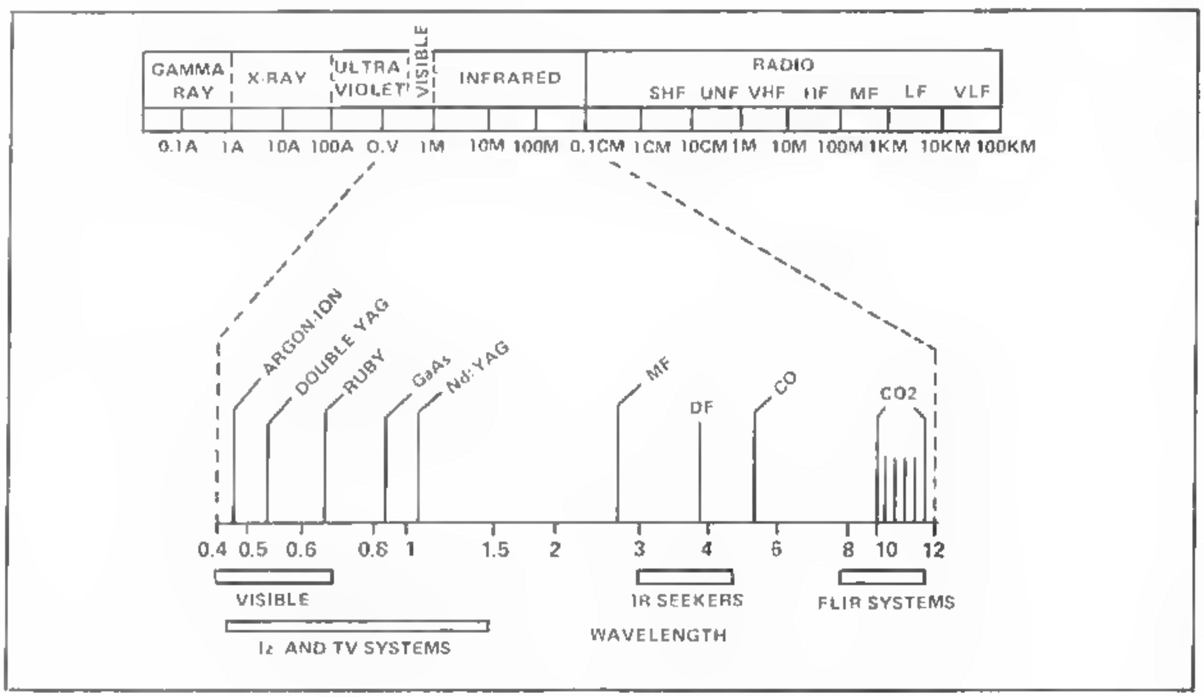


Figure 12-5. Sensors and Lasers in the Electromagnetic Spectrum

12.5.4 Laser Guided Bombs and Spot Trackers. This section deals with target designation tactics and considerations for laser guided bombs. Refer to NWP 55-6-OV10A/D, Vol. II for this information.

12.6 FLIR ORDNANCE DELIVERY

This section discusses utilizing the FLIR and the laser to deliver on board air-to-ground ordnance. It should be noted that the actual mechanics of target Detection-Acquisition-Identification have been discussed earlier and will not be covered here. It should also be noted that these procedures are very *labor intensive* for the aircrew. Because of this, aircrew coordination is critical and should be planned and briefed in detail. Particular attention should be paid to the critical aircrew responsibilities involved in flying the aircraft to ensure terrain avoidance, safe separation from other aircraft, etc. These tasks must not be neglected during FLIR ordnance delivery.

12.6.1 FLIR System and the Optical Gunsight. Although the FLIR turret is located approximately 5 feet ahead of and below the pilot's optical sight, their settings are both based on or calibrated to the longitudinal axis of the aircraft. Therefore, the respective *lines-of sight* of the two devices should be parallel and not more than a few feet apart when adjusted properly. At the slant ranges that ordnance is normally delivered, this separation should have little or no effect on the accuracy of the ordnance to be delivered. This also means that the same delivery data, to include the mil sight setting, that is used with the optical sight can be used with the FLIR. In order to set a desired mil setting on the FLIR, dial in the appropriate number of mils using the FLIR gimbal angle depression control on the receiver/transmitter-converter control located in the observer's cockpit. The mils counter will indicate the setting established. Then, at the appropriate time, the observer must move the mode switch to the forward position. This will cause the FLIR to slew forward to a position of zero degrees of azimuth and be depressed the set number of mils. It is recommened that the optical sight be checked against the FLIR *sight* once airborne, and prior to ordnance delivery, to ensure that they are both looking at the same spot on the ground. If inaccuracies appear either during this check or during the actual ordnance delivery, the aircrew should not automatically assume that the FLIR is at fault. Many other variables could be at fault, some of which are discussed in Chapter 3. If it is determined that the FLIR and optical sight are not looking at the same spot on the ground with the FLIR in forward and the proper mils set into both *sights*, the position (POS) FLIR mode may be used, if it is determined that the optical sight is accurate. While this will not improve accuracy if the optical sight is misaligned, it can overcome errors in FLIR alignment. To prepare the FLIR POS mode for use as a gunsight, the pilot must first dial the mil setting required for the type ordnance delivery to be used into the optical sight, while the AO/SAC(A) places the FLIR in WIDE and POS with 0 azimuth and 0 or slightly negative elevation set. The aircrew will agree on an easily identifiable geo point, and while the pilot maintains the optical sight alignment on the point while flying towards it, the AO/SAC(A) shall identify the point and center it in the FLIR screen by manipulating the FLIR azimuth and elevation knobs. Once centered, the AO/SAC(A) shall place the FLIR in NARROW and refine the solution. The FLIR is now effectively boresighted to the optical gunsight, and the POS mode may be substituted for the forward mode in FLIR ordnance delivery.

WARNING

If the POS mode is used as a gunsight, extreme caution must be exercised to avoid moving the FLIR azimuth and elevation settings once aligned with the optical sight. Any intentional or inadvertent movement of these knobs, regardless of how slight, destroys FLIR alignment and renders any firing solution inaccurate and inherently unsafe.

12.6.2 Mission Planning. As always, mission planning should take into consideration the threat, and the best way to defeat it. Utilizing the FLIR as a gunsight allows the aircrew to maximize surprise at night because it is not necessary to artificially illuminate the target to engage it while performing such tasks as close in fire support, etc. Careful attention should be given to data provided through the use of the electo-optical tactical decision aid to determine the maximum ranges at which targets may be acquired. This information would then provide the basis for the aircrews weaponeering functions. The concept here is that we want to utilize weapons and tactics that will keep our exposure time to the threat as short as possible, while still enabling us to accomplish the mission. If the aircrew determines that a dive delivery is required, as in a rocket or gun attack, it should be kept as shallow as possible. Additionally, the maneuver should be conducted with more altitude separation than normal between the pattern altitude and firing altitude to allow more time for FLIR operation and target tracking. The release error sensitivity tables

in Vol. I.1 will provide good information on expected accuracies. The aircrew needs to be aware of the potential for error based on these tables, their own proficiency, and the inherent variables in the system when evaluating their ability to accomplish the mission successfully. It should also be *emphasized* that these factors *must* be considered when delivering ordnance in close proximity to friendly forces.

12.6.3 Aircrew Coordination. Each aircrewman will, over time, develop their own techniques and procedures based on their own preferences and experience level. Some recommended procedures will be given later, but first we need to look at some basic rules of thumb for aircrew coordination.

12.6.3.1 Aircrew Communication. The observer in the rear cockpit will exercise primary control over the FLIR system while the pilot will obviously fly the aircraft and deliver the ordnance. They both need to establish a running commentary with each other over everything they do, in a continuing *challenge* and response manner. The pilot's commentary should cover control inputs, aircraft altitude (and terrain separation), attitude, engine performance conditions, weapons switchology, etc. The observer's commentary should cover, as a minimum, all FLIR and LASER control inputs. Examples of this are polarity, field of view, movement of the FLIR turret, laser on/off, laser range, etc. Both aircrews should double-check each other on these items. Also, both aircrews should verbally agree that the target seen on the FLIR screen is indeed the target to be attacked. Any disagreement or uncertainty should result in an immediate termination of the attack and a wings level climb to a safe altitude if in a dive. Once the uncertainty is removed, the aircrew may reevaluate the situation and either resume the attack or, if necessary, abort the mission.

12.6.3.2 Aircrew Scan. The images on the FLIR screen are often difficult to interpret, especially for the pilot because of the smaller size of his video indicator and because he is not controlling the FLIR. Both aircrews need to ensure that they do not spend an excessive amount of time looking at the video indicators at the expense of their other duties. It is essential that a good *scan pattern* be maintained. A good procedure to use is to scan continuously in the following manner.

1. First look at the aircraft instrumentation to determine what the aircraft is doing, i.e., altitude, attitude, airspeed, timing, etc.

2. Then look at the azimuth and elevation cursors on the video indicator to determine where the FLIR is looking in relation to aircraft. If you have done a careful map study during mission planning and know about where you are over the ground, you should have an approximate idea of what you will see on the video indicator.

3. Now look at the images on the video indicator and interpret them. A quick map cross check may be necessary at this point, as well as communication between aircrew to identify key terrain features, targets, etc.

4. Other — at this point, the aircrew should do anything else required, such as check fuel state, verify the wingman's position, cross check the navigation systems to ensure location, turn on/off the MASTER ARM switch, etc. Then repeat the cycle.

5. While using the FLIR as a gunsight on an ordnance delivery run, there is a danger that both aircrew may become absorbed in viewing the FLIR screen, to the detriment of other tasks, such as terrain avoidance. To reduce this risk, once the AO/SAC(A) switches the FLIR into FORWARD or POS, he should transition to a collision avoidance scan until the aircraft nose passes above the horizon following a dive delivery, or until ordnance is released on a level delivery.

12.6.4 Ordnance Delivery. Now that we have discussed some of the factors involved in aircrew coordination and mission planning, lets look at some recommended procedures for ordnance delivery using the FLIR as a gunsight. It should be noted that it is not necessary to actually deliver ordnance to practice these maneuvers and techniques. They may be practiced at any time as long as it is properly briefed and has the approval of the commanding officer.

12.6.4.1 Level Deliveries (CBUs, ADSIDs, Rockets, Guns, Etc.). The first method discussed will be the recommended procedures for a level delivery. Level delivery considerations and the procedures for using the laser are covered in Chapter 3, Vol. I, and will not be discussed here. This technique may be used in either a standard *IP to target* attack, or from an oval *racetrack* pattern.

1. Set the desired mil sight setting with the FLIR gimbal angle depression control. Convert the mil setting into degrees and mentally note this number for using when scanning the azimuth and elevation cursors on the VIDEO INDICATOR.

2. Place the FLIR in the wide field of view and adjust polarity, brightness, and contrast.

3. Fly directly over the IP and head straight to the target. If utilizing a racetrack pattern, extend downwind while attempting to keep the FLIR oriented on the target area, and the target if possible. This should be done with the FLIR in the manual track/computer track mode.

4. As early as possible, establish the aircraft in a wings-level attitude with the nose on the target. Locate and identify the target/target area as you approach it. The elevation cursor will be moving downwards as you get closer. The observer will need to provide the pilot input to correctly position the aircraft *nose on to the target.* Corrections should be smooth and gradual using rudder pedals and flat turns.

5. When you approach the target area and the elevation cursor reaches a point 3 to 5° short of that number that matches the mil setting, switch into forward mode. The operator may desire to switch to narrow field of view at almost any time during this process. Additionally, the operator should attempt to *lock* onto the target or onto a nearby thermally significant object and *offset* to preclude having to continuously manually orient the FLIR.

6. Upon switching to the forward mode, the target may appear to *jump* off of the screen. This is normal, and it should eventually slide back into view at the top of the screen.

7. Once it does, direct the pilot to use rudders to center the cursor on the target. It should track from top to bottom of the cursor. Of course, the weapon should be delivered as the target approaches the center of the cursor.

8. It is very important that the pilot maintain altitude and a wings-level attitude during the entire evolution.

9. After weapons release, the aircrew may elect to maintain the FLIR oriented on the target to provide BDA. Additionally, laser ranging and video recording may be conducted throughout the delivery.

12.6.4.2 Dive Delivery (Rockets, Guns). For dive deliveries, the procedures used for firing ordnance during the day can be used at night. The biggest problem is determining aircraft distance from the target. By using the LASER or a navigational system, this distance should be able to be determined. Two patterns or profiles can be used to get the aircraft into position for ordnance delivery: push-over method or roll-in method.

1. Push-Over Method — this method is very similar to the level delivery procedures. The procedure is as follows:

(a) Prior to making your run-in, determine the degrees of dive for the specific delivery and the mil setting required. Set the mils into the FLIR gimbal setting.

(b) Depending on the desired starting altitude and personal preference, set the FLIR field of view. Recommend using the wide field of view until just before ordnance release.

(c) The target is tracked in the center of the cursor using MANUAL TRACK until the desired degrees of depression are reached (10° for a 10-degree dive delivery, 20° for a 20-degree dive delivery, etc.). At this point, you should be at your push-over point.

(d) As the pilot pushes the nose over, select FORWARD on the FLIR control panel and the NARROW field of view setting.

(e) If all went well, at the predetermined delivery altitude, the ordnance can be released.

2. Roll-In Method — the roll-in method is probably the most difficult as it does not allow the crew to keep the target in the FLIR the whole time. Finding the target coming down the chute can be difficult. The recommended roll-in method is as follows:

(a) Determine the mil setting and place it into the FLIR gimbal depression control.

(b) Select MANTRACK on the FLIR control panel and place the cursor on the target. Either wide or narrow field of view can be used.

(c) Track the target to the abeam (left/right) position. If you track the target past 90°, you may get a bit more tracking time coming down the chute. Pay close attention to the gimbal indicator for elevation as it should not go below your intended dive angle.

(d) As the pilot rolls in, select FORWARD on the FLIR control panel.

(e) When the pilot rolls out, the target should be tracking from the top of the cursor downward.

(f) Once the target is inside the four corners box, select narrow field of view.

(g) Deliver the ordnance at the predetermined altitude and airspeed, with the cursor on the target.

12.6.5 Options. The procedures discussed above are workable options for using the FLIR as a GUNSIGHT. The individual aircrew may elect to modify them somewhat based on operator proficiency, FLIR picture clarity, or the operational situation.

PART IV

Enemy Defenses and Friendly Countermeasures

CHAPTER 13

Antiaircraft Artillery (AAA) and Surface-to-Air Missiles (SAM) Threat

Refer to MCM 3-1, Vol. II, Threat Reference Guide and Countertactics.

CHAPTER 14

Fixed- and Rotary-Wing Threat

Refer to MCM 3-1, Vol. II, Threat Reference Guide and Countertactics.

CHAPTER 15

Ground Threat

Refer to MCM 3-1, Vol. II, Threat Reference Guide and Countertactics.

CHAPTER 16

Electronic Warfare Principles

16.1 INTRODUCTION

Electronic warfare (EW) is a primary factor in the conduct of military operations. It pervades the whole of air warfare. Included within its purview is the application of EW equipment and those EW capabilities installed in specifically configured aircraft designed to support air and surface operations. The employment of the detection modes of electronic warfare begins prior to the initiation of conflict by using electronic warfare support measures (ESM) to locate and determine the status of the enemy threat. Upon the initiation of overt hostilities, electronic warfare support measures and electronic countermeasures (ECM) are used to support elements of the friendly forces. Electronic counter-countermeasures (ECCM) are applied judiciously as well to support friendly forces. The electronic warfare mission is to assist in the establishment by electromagnetic means of the military operational environment which will assure, to the greatest extent possible, that tactical initiative continually rests with the commander of friendly forces.

16.2 ELECTROMAGNETIC ENERGY

Electromagnetic energy and some of the terms defining its action must be described. Electromagnetic energy is one of several forms of energy. Most people are familiar with the process of transmitting torque (mechanical energy) from a motor (source) to a wheel (load) through a shaft (medium). This is an excellent mechanical analogy to the transmission of radio waves (electromagnetic energy) from a transmitter to a receiver through the atmosphere or space.

The traveling electromagnetic energy is comprised of the following two components:

1. An electric field
2. A magnetic field.

The two component fields travel through the medium together and in phase with each other. They are mutually perpendicular and perpendicular to the direction of travel. These properties are illustrated in Figure 16-1. The energy is traveling from left to right in the figure. The electric field is vertical and the magnetic field is horizontal.

Some useful terms describing wave phenomena may be explained as follows:

radio wave propagation. Refers to the movement of radio waves through any medium.

period of oscillation. The time (t) in seconds required to complete one cycle of the oscillation (top of Figure 16-1).

frequency. The number of cycles completed in 1 second. The unit of frequency measurement for the electromagnetic spectrum is the hertz (Hz) (Figure 16-1).

wavelength. The distance the wave front will travel in the time of one cycle. If this energy could be photographed, the wavelength would represent the length of one complete cycle in space.

amplitude of oscillation. A measure of the maximum displacement of the wave from its null or undisturbed condition.

velocity of propagation of electromagnetic energy. Approximately 300,000,000 meters (or 186,000 miles) per second.

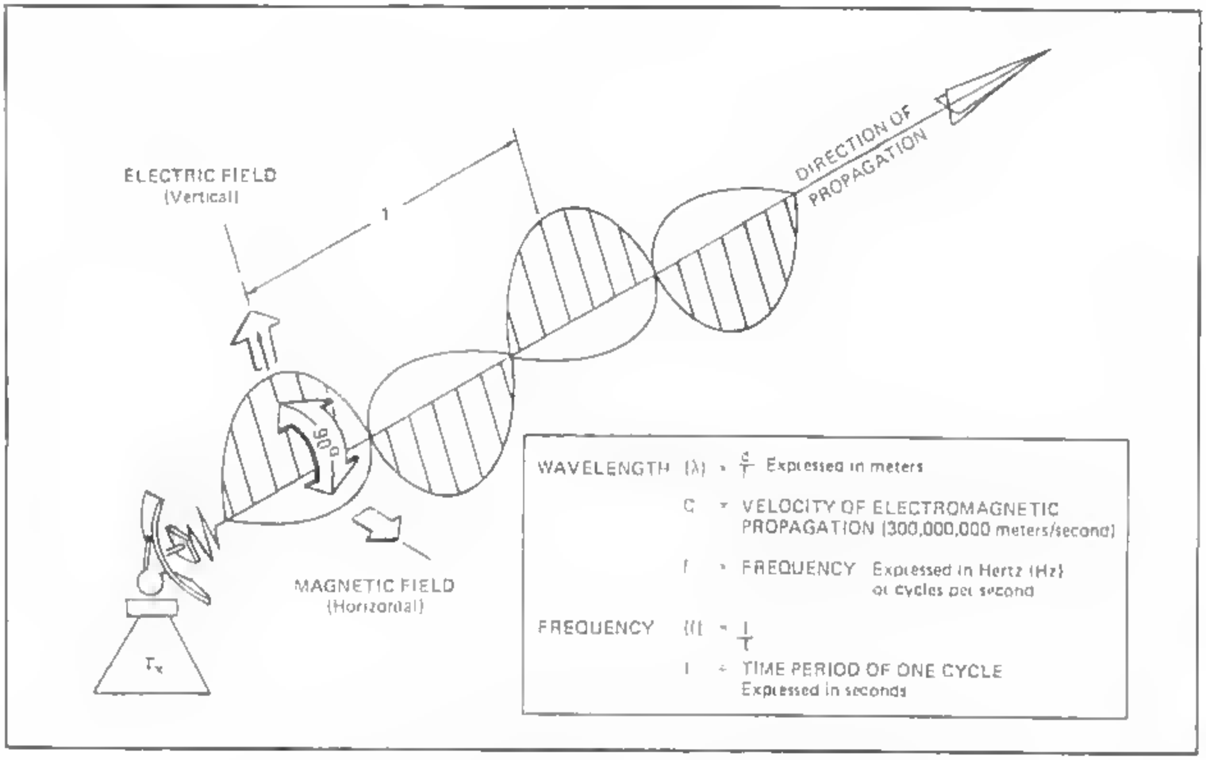


Figure 16-1. Electronic and Magnetic Fields in a Travel Wave

16.2.1 Modulation. Modulation is the process of impressing information on an electromagnetic wave. The four types of modulation are:

1. Amplitude modulation (AM) — consists of varying the amplitude of the radio frequency (RF) energy wave in accordance with the changes in an imposed signal.

2. Frequency modulation (FM) — consists of varying the frequency of the RF energy wave in accordance with the changes in an imposed signal. The information is represented by the rate and amount of frequency change.

3. Phase modulation — consists of varying the phase of the RF energy wave in accordance with the changes of the imposed signal without changing the amplitude. The effects are similar to frequency modulation.

4. Pulse modulation — consists of grouping the RF energy wave into specified pulses. The information is carried by a change in amplitude, number, or duration of the pulses.

16.3 BASIC RADAR CHARACTERISTICS

The obviously close relationship between electronic warfare and radio detection and ranging (radar) systems requires an explanation of radar characteristics. Radar is a device that emits and focuses a powerful RF beam and displays a target's range, altitude, azimuth, velocity, or a combination of these parameters, using reflected RF energy. Different types of radars and their functions are discussed in the following paragraphs.

16.3.1 Continuous Wave (CW) Doppler Radar. An elementary CW Doppler system is shown in Figure 16-2. Such a system contains a transmitter, receiver, indicator, and appropriate antennas. The basic system cannot detect range. However, it is excellent for detecting the closing velocity of a target.

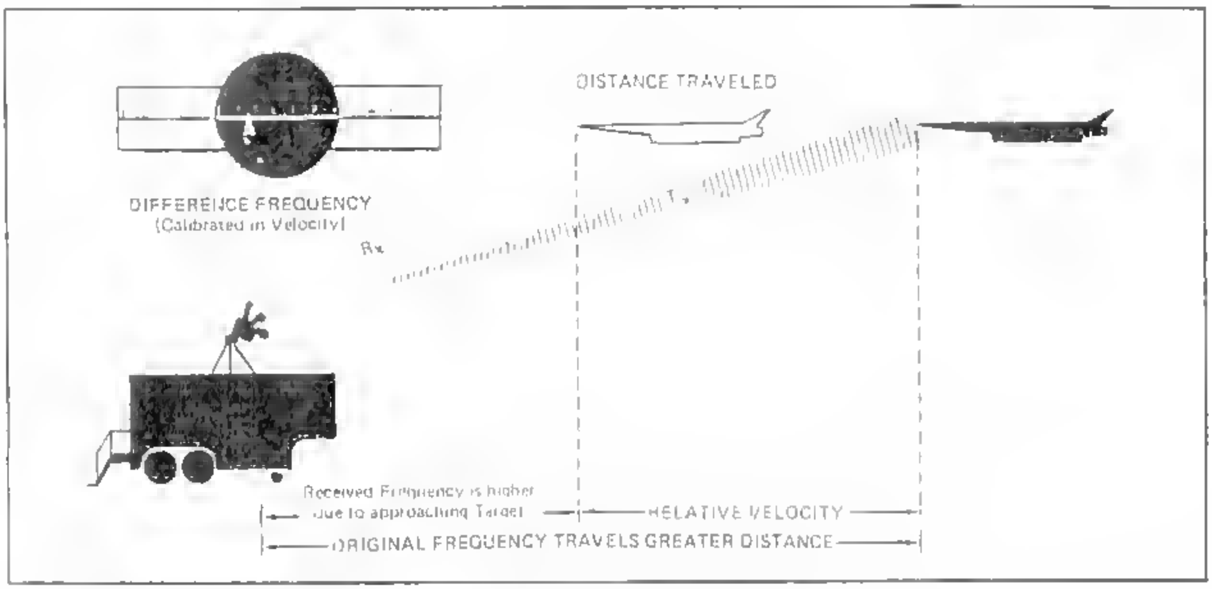


Figure 16-2. CW Doppler Radar

The transmitted RF energy is radiated, strikes the target, and returns to the receiver. The frequency of the returning RF echo is compared with the frequency of the transmitted energy. If the target is moving relative to the transmitter, the returning energy exhibits a different frequency, a phenomena known as Doppler shift. This difference in frequency is amplified, processed, and sent to the indicator as a target velocity.

Use of the basic Doppler is limited because of its inability to determine range or to detect targets with zero velocity relative to the radar transmitter (Figure 16-3). It is also difficult to obtain the high RF power required to produce detectable RF echoes from distant targets. This is true of all continuous wave systems.

16.3.1.1 Frequency Modulated CW Doppler Radar. By modulating the frequency of the CW Doppler radar, it is possible to measure range and relative velocity. Consider an FM-CW Doppler whose frequency is being changed at constant rate over time. The frequency returning from a stationary target to the radar receiver lags the transmitted frequency by some time. Range measurements may be accomplished by determining the frequency difference between the transmitted and received frequency. If the target is moving relative to the radar, an indication of that relative velocity and target range can be obtained. FM-CW Doppler radar still has the same power disadvantages of the basic Doppler since it too is a CW system.

16.3.2 Pulsed Radar. To overcome the serious range limitations inherent in a CW system, the pulsed radar system was developed. It is designed to generate RF energy at extremely high peak power while the average power remains relatively low. This makes long-range operation possible. The increased range capability and adaptability to most search or tracking problems make the pulsed radar system the one generally used by military forces.

The transmitted RF energy strikes a target that reradiates the energy in many directions. A small part of this energy is directed back toward the radar receiver. The receiver amplifies this echo (reflected RF energy), processes it into a video pulse of current or voltage, and displays the pulse on a cathode ray tube (CRT) indicator. The CRT presentation used by a radar is determined by the information desired. The CRT may present a simple measurement of range (A scope); chart an area by tracing the surrounding terrain (plan position indicator scope); display range and altitude (range height indicator scope); or identify a target for tracking (G scope). Four common presentations are shown in Figure 16-4

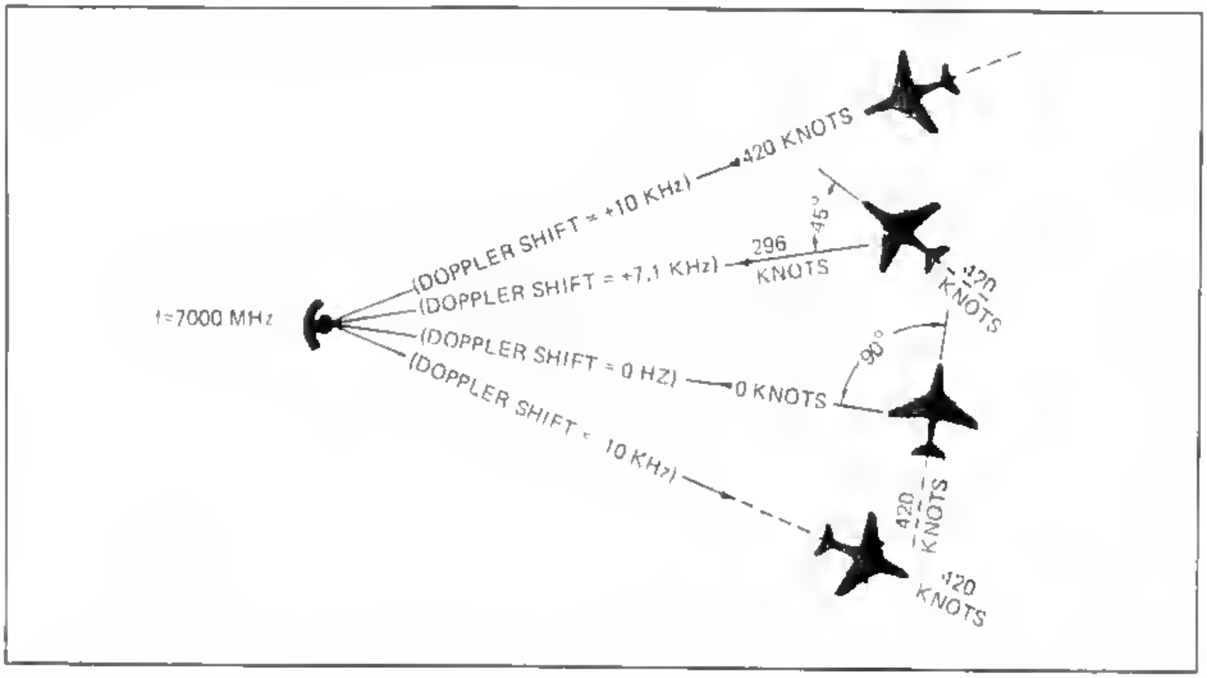


Figure 16-3. Doppler Shift and Relative Velocity

16.3.2.1 Technical Characteristics of a Pulsed Radar. The operating requirements of a pulsed radar system determine the operating characteristics of the radar. As with any radar system, these requirements include the detection range, range resolution, azimuth resolution, and any other specifications that are applicable to the system. The operating capabilities of a radar system are determined by four characteristics:

1. Pulse width
2. Pulse recurrence frequency
3. RF
4. Scanning pattern.

The pulse width and RF determine the precision of the radar. The antenna scanning pattern determines the angular resolution and speed of gathering data. The pulse width and pulse recurrence frequency determine the operating range.

16.3.2.1.1 Pulse Characteristics. The terms describing pulse characteristics may be explained as follows:

pulse width (PW). The duration in time that the transmitter is actually transmitting RF energy. This duration in time is measured in microseconds.

pulse repetition frequency (PRF). The number of RF pulses generated per second. PRF normally falls within the audio range (16 to 20,000 Hz).

pulse recurrence time (PRT). The time it takes a radar to complete the cycle of operation: transmit a pulse, receive the echo, and prepare the transmitter for the next pulse. PRT is the reciprocal of PRF.

pulse repetition interval (PRI). The time between pulses.

peak power (P_{pk}). The maximum level of power produced for the duration of the PW.

average power (P_{avg}). The amount of continuous power that must be provided by the power supply. Average power, like peak power, is measured in watts.

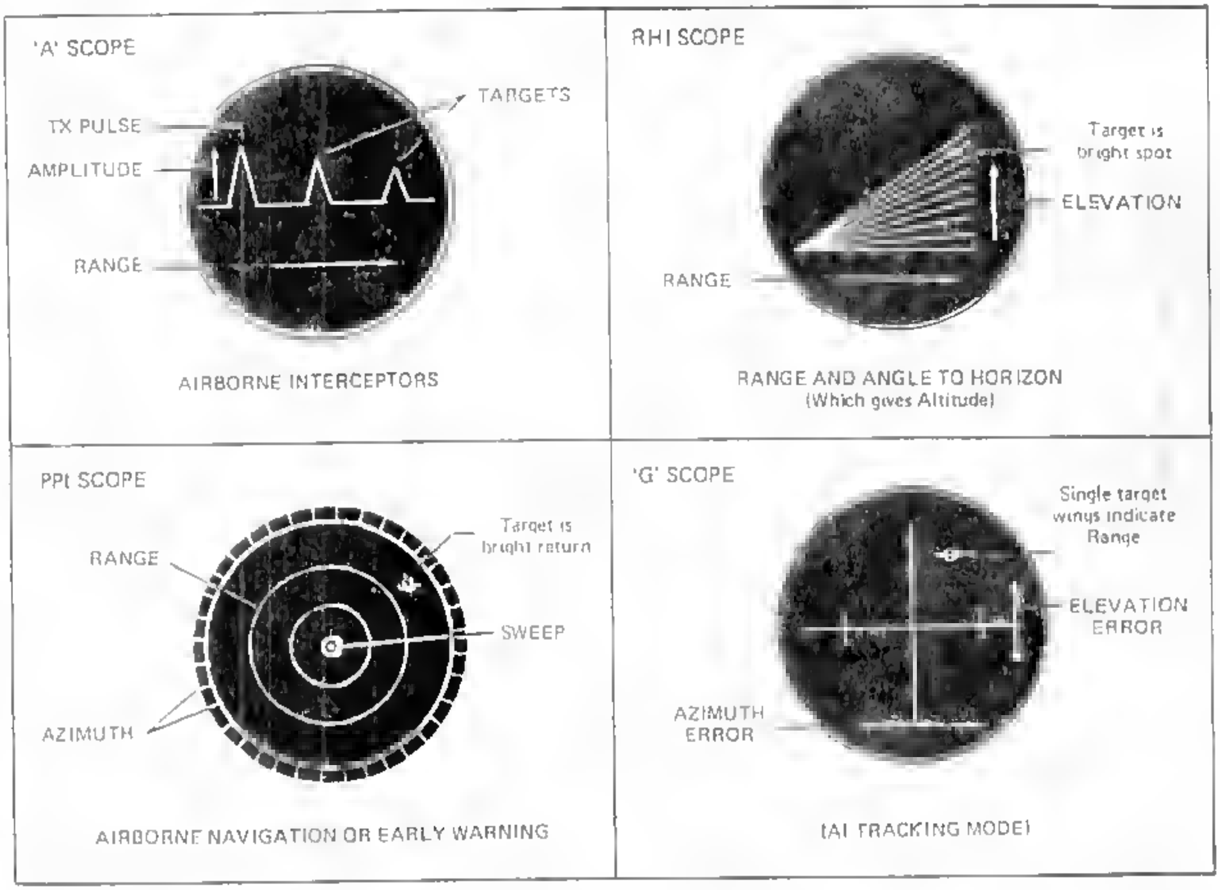


Figure 16-4. Scope Images

16.3.2.2 Performance Characteristics Related to Pulse Specifications. The PW limits the minimum radar range. Since the transmitter signal is many times stronger than any echo, it must be turned off before an echo may be distinguished from the transmitter pulse. This means that no signals can be received from targets closer than one-half the distance traveled by a signal pulse during its transmission interval. For example, if the pulse width is 1 microsecond, then all targets closer than 1/2 microsecond in time (492 feet or 150 m) will be obscured by the transmitter pulse.

The pulse width also determines the ability of the radar to separate two targets having the same bearing but at different ranges. In Figure 16-5, the targets are separated by one-half the pulse width. T2 in A shows the pulse 1/2 microsecond after first encountering the target. T3 shows the pulse slightly beyond the target. Note that the echo from the second target is joining the echo from the first target. Combined echoes of this nature will show a single pulse on the indicator; therefore, targets separated by only one-half the pulse width or less will not be resolved in range. If targets are separated by a distance slightly greater than one-half of the pulse width, they may be readily resolved as shown in Figure 16-5.

The PRF determines the maximum theoretical range of the radar. The transmitter must remain quiet during the listening time (time that targets are received and displayed on the indicator). If the transmitter is allowed to pulse a second time before all echoes return, range to targets would be ambiguous since it would be impossible to determine the reference pulse. This means that the transmitter pulse must be timed so that the PRI is greater than the time required for echoes to return from the maximum

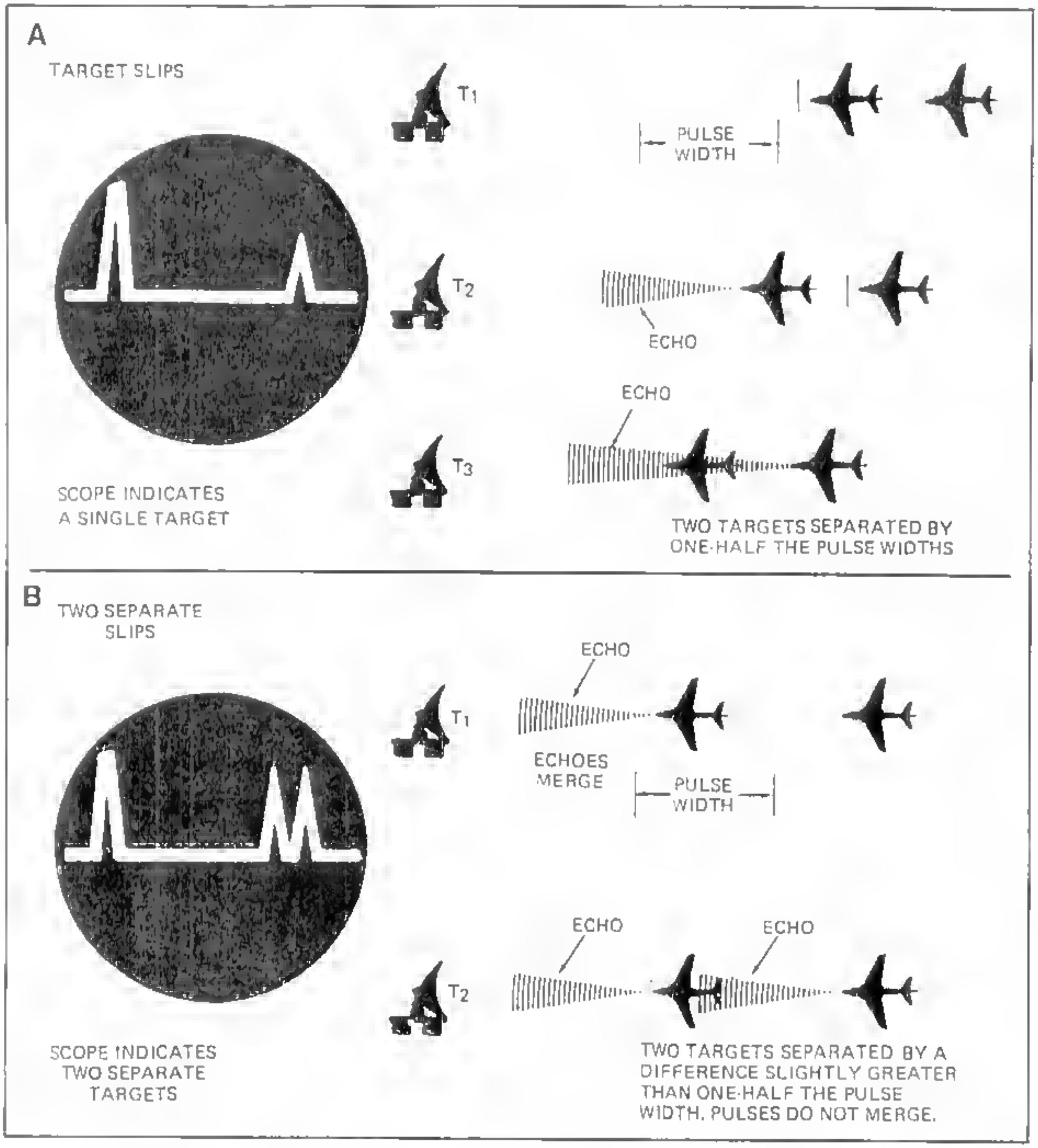


Figure 16-5. Range Resolution

possible range. Consequently, long-range radars must have a relatively low PRF to display all returning echoes.

Another important consideration concerning the PRF is the scanning rate. The rotational speed of the antenna (scanning rate) is limited by the PRI. If the antenna is rotating too fast, insufficient RF echoes are received from a given target. In radar equipment designed for long-range detection, the scanning rate must be slow enough for a sufficient number of echoes to be received from a given target.

If the system is designed for short range, it will have a narrower PW for range resolution and the PRF and scan rate will increase proportionally to increase the speed of gathering data. All of these changes decrease the range, but the designers are willing to pay this price to increase the overall accuracy of the radar system.

The frequency of a radar set affects several operating characteristics. One of the prime requirements of a radar is a well-shaped RF beam. To shape a beam of RF energy, its wavelength must be short in comparison to the antenna reflector size. Because of this property, high frequencies are generally preferred in precision radars. On airborne radars, antenna size is especially limited and these radars usually operate at frequencies above 8000 MHz. With ground-based tracking radars, the physical size of the antenna can be increased and the operating frequencies will go as low as 2500 MHz. For long-range, early warning radars, frequencies in the VHF range (30 to 300 MHz) are common since atmospheric attenuation increases with frequency. These early warning radars are designed primarily for maximum range detection rather than target tracking.

16.4 BASIC RADAR CATEGORIES

Radars can be divided into general categories by their function: radars that provide target detection (early warning and height finding), target location (acquisition and ground control interceptor (GCI)), target engagement (antiaircraft artillery (AAA)), surface-to-air missile (SAM), and airborne interceptor (AI) control. Radars that provide a particular category can usually be grouped by similar parameters. The following paragraphs give brief descriptions of the type radars found in these categories.

16.4.1 Target Detection. Target detection radars include early warning and height-finder radars.

16.4.1.1 Early Warning. The early warning radar is a high-power system used for long-range detection of aircraft. Its main purpose is early detection as opposed to location accuracy. It is characterized by relatively long pulse widths (2 to 20 microseconds), low PRF (100 to 400 pulses per second), and RF operation in the range of 50 to 1400 MHz. The long PWs allow the transmission of very high power (1 to 10 megawatts). The low PRF allows very long listening times, and ranges up to 300 nm are common. Recently, early warning radars using pulse compression have been deployed. These systems combine the transmission of long pulse width (10 to 100 microseconds high power on target) with complex RF waveforms to obtain excellent detection and range resolution on long-range targets.

Early warning radars generally use a periodic, circular azimuth scan. A narrow fan-shaped beam is rotated in a full circle round a fixed-vertical axis. Typically, the beam is shaped to provide a 2° azimuth and 10° to 30° elevation beamwidth. This gives acceptable azimuth resolution and good altitude coverage. This fan-shaped beam is rotated slowly so that several successive pulses will hit and reflect from each target. Target detection is generally provided manually by an operator using a PPI display of direct radar video.

16.4.1.2 Height Finder. While the early warning radar coverage includes varying altitudes, height-finder radars provide more accurate information regarding target elevation. The height-finder radar is similar in many respects to the early warning radar except that the beam shape and scan type provides a narrow beam (typically 1° to 2°) in the vertical plane and a wider sector in the horizontal plane (Figure 16-6). This narrow, fan-shaped beam is then cycled up and down mechanically or electronically in an arc from about -2° to 32°. Other typical characteristics of height-finder radars include PW of 2 to 3 microseconds and PRFs of 200 to 400 pulses per second, with an effective range of about 200 nm. The height-finder radar typically operates at RFs from 2500 to 10,000 MHz.

Height-finder radars are generally used in conjunction with early warning radars. Newer systems of both types often use a frequency scanning rather than a mechanical scanning technique to move the antenna beam in azimuth or elevation. Most systems that employ electronic scanning mechanically rotate the

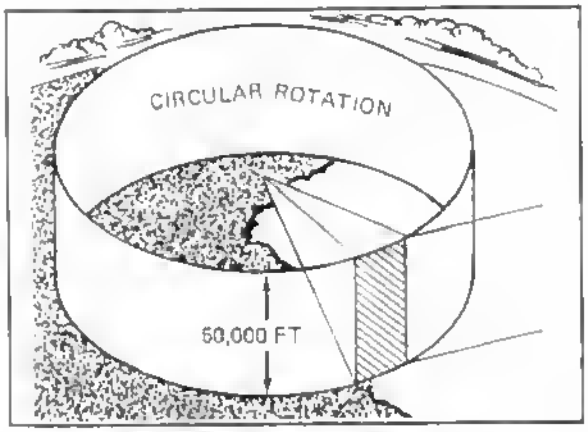


Figure 16-6. Height Radar Scan Patterns

antenna in azimuth and electronically vary the frequency (and therefore the beam position) in elevation.

16.4.2 Target Location. Target detection data from early warning or height-finder radars is used in a typical air defense network to provide weapon systems with particular target location data. This data is used by target acquisition radars associated with ground weapon systems and by GCI radars associated with airborne weapon systems.

16.4.2.1 Acquisition Radars. Associated with ground weapon systems such as antiaircraft artillery or surface-to-air missiles is a variation of the early warning radar known as the *acquisition radar*. It is similar in function to the early warning in that it provides range and azimuth information used in target selection by target-tracking radars. Range and azimuth resolution are improved along with the data collection rate. Acquisition radars have relatively shorter PWs (typically 1 microsecond), higher PRFs (perhaps 500 to 800 pulses per second), and narrower beamwidths. In addition, the azimuth scan rates are increased. The systems are generally as mobile as the associated AAA or SAM system and sometimes are integrally mounted on the same vehicle as the target-tracking radar. However, early warning radars may also provide the acquisition radar function for weapon systems. With the improvement in target location accuracy comes a sacrifice in range. The maximum theoretical range drops to around 150 nm, and the actual ranges are even less because of the operating role of the radar. These radars normally operate at higher frequencies (about 2000 MHz) to facilitate providing better angle accuracies with physically smaller antennas, but radars operating below 1000 MHz are often used for target acquisition.

16.4.2.2 Ground-Controlled Interceptor Radars. Information from the early warning and height-finder radars, which provide general target location in azimuth, elevation, and range, is provided to the portion of the air defense network used for ground-based airborne interceptor control. These sites employ radars that combine general early warning, height-finder, and special early warning radars that have a height finding capability. These sites are known as ground-controlled interceptor sites. Early warning radars with height finding capability are known as *GCI radars*.

16.4.3 Target Engagement Radars. Target engagement radars supply information to a weapon system that is used to direct weapons toward a target. These radars detect the target, track it, and continually update the target information to a weapon system computer. The computer automatically directs the associated weapons (guns or missiles).

The types of radars used for target detection and location are not suitable to supply target engagement information because of the increased accuracy and data rate requirements. Radars that supply information for target engagement generally have narrow pulse widths (0.1 to 1.0 microsecond), high PRFs (1,600 to 10,000 pps), and operate at RFs above 2500 MHz. These radars use relatively narrow antenna beamwidths (1° to 5°) in both azimuth and elevation to supply the accurate target position information necessary for engagement by weapon systems. The radars generally have two operating modes:

1. Target acquisition (in which course target location information is used by the engagement radar to initiate electronic target tracking)

2. Track (in which the target's position is electronically followed in range and angle).

Most weapon-control radars have some capability for the operator to manually track targets in range and angle, although in some cases the manual tracking accuracy may degrade the associated weapon system's performance.

There are three types of weapons that use radars for engagement. These are antiaircraft artillery, surface-to-air missiles, and weapons controlled by airborne

interceptors. The following paragraphs will discuss the radars used by each system for target acquisition and target track leading to weapon engagement.

16.4.3.1 Antiaircraft Artillery (AAA) Control. Radars used to direct AAA weapon systems are generally low-powered, precision, single-target tracking systems that use a variety of scanning patterns to aid in target acquisition.

16.4.3.2 Surface-to-Air Missile (SAM) Control. Radars used to control SAM systems generally require different performance characteristics. SAM radars are generally used for longer range operations than AAA systems and, therefore, must have higher power and lower PRFs to provide this extended range capability. However, tracking accuracy must not suffer at these longer ranges, and SAM radar systems typically have antenna beam widths of 1° to 4° and pulse widths of 0.25 to 1.0 microsecond to provide the necessary accuracy.

16.4.3.3 Airborne Interceptor Weapon Control. Airborne interceptors use radars that have capabilities to support the variety of weapons carried by individual interceptors. Systems that employ air-to-air missiles must utilize relatively sophisticated radar techniques, while interceptors that employ only air-to-air guns often use less sophisticated radars having only ranging capability.

Airborne interceptor radars generally operate at RFs above 8000 MHz, with PRFs above 1,000 pps, and pulse widths between 0.2 and 1.0 microsecond.

16.5 DIVISIONS OF ELECTRONIC WARFARE

The importance of electronics in modern warfare must never be underestimated. Without ECM, the present day electronically controlled weapon systems could inflict unacceptable losses on an attacking force. Likewise, without proper ECCM, electronic defense systems could not function effectively in a hostile ECM environment. There are three primary divisions of electronic warfare.

16.5.1 Electronic Support Measures (ESM). This division encompasses those functions of electronic warfare dealing with the search, interception, location, recording, and analysis of radiated electromagnetic energy for the purpose of exploiting such radiations in support of military operations. Thus, ESM provides a source of electronic warfare information required to conduct ECM, ECCM, threat detection, and radar warning, avoidance, or homing. Electronic support measures can be provided by many sources, including EA-6, EF-111, E-2, and E-3 aircraft.

16.5.2 Electronic Countermeasures (ECM). This division of electronic warfare encompasses any actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum. ECM includes jamming, deception, and destruction techniques.

16.5.2.1 Jamming. Jamming is the deliberate radiation or reradiation of electromagnetic energy with the object of impairing the use of electronic systems used by the enemy.

Jamming is effective because of certain inherent radar characteristics. Radar receivers must be extremely sensitive to receive the small amounts of energy reflected from targets. It is therefore relatively easy for a jammer to generate power greater than the reflected energy of the target.

Electronic jamming is divided into two general categories:

1. Saturating or noise

2. Confusion or deception.

Noise jamming depends on returning more power to the radar receiver than it receives from the reflected echo (Figure 16-7). The introduction of false or delayed signals into enemy receiving equipment to confuse normal intelligence is labeled confusion or deception.

The requirements for noise jamming vary with the system to be countered, but must include three general capabilities:

1. The jamming transmission must be essentially continuous.

2. The jamming power must be great enough to overcome the receiver.

3. The jammer should be able to match the victim signal in frequency range and should be able to direct the jamming energy toward the victim receiver.

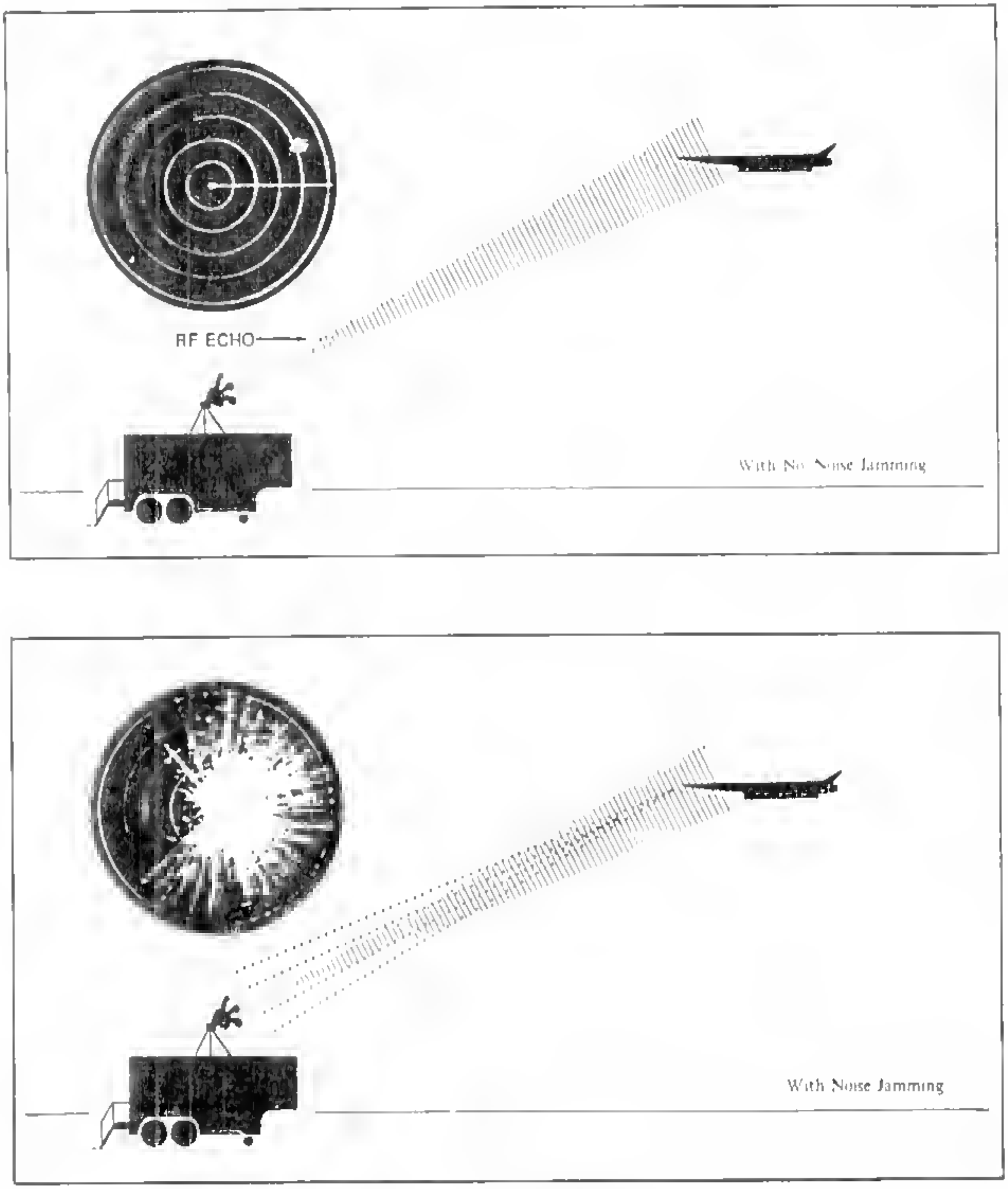


Figure 16-7. Radar Scope Noise Jamming

16.5.2.2 Deception. The effectiveness of deception for confusion devices depends on a weapon system's susceptibility to false targets. Deceptive systems can be more complex than continuous noise jammers, but more efficient in use of radiated power. Major problems in using these devices include building them in small, reliable packages and keeping their techniques current with capabilities of enemy weapon systems.

16.5.2.2.1 Chaff. One of the earliest but still effective ECM devices is chaff. Chaff is a resonant substance, such as metal, fiberglass, or an aerosol, used to reradiate electromagnetic energy to create a radar echo for ECM purposes. Chaff tends to saturate the capability of a radar and to create confusion and hesitation among ground radar operators. Chaff can reduce losses to interceptor and fire control radars.

Chaff is not infallible. Its greatest weakness is its lack of horizontal velocity. Once dispensed from an aircraft, the chaff strips quickly lose their horizontal speed. Many radars have antichaff circuits designed to exploit this weakness. Another weakness of chaff is its high rate of fall and consequent limited period of effectiveness.

16.5.2.2.2 Radar Decoys. Radar decoys are expendables that can be launched by penetrating or supporting friendly aircraft. Their purpose is to replicate many times the radar signature of the target aircraft, thus providing enemy radar operators an unmanageable number of false targets.

16.5.2.2.3 Flares. Not all electronic weapon systems employ the radio portion of the electromagnetic spectrum. Many utilize the infrared (IR) portion and must also be defended against with the use of decoy flares. Flares are designed to counter IR receivers that depend only on IR energy emitted by a target aircraft. All bodies above absolute zero temperature emit IR radiation. Flares can be ejected from target aircraft to radiate IR energy greater than that radiated by the target. As these burning flares are ejected from the target aircraft, they can present a more inviting target to an IR sensitive weapon.

16.5.2.3 Destruction. Destruction of selected components of enemy electronic defenses is the most positive countermeasure. Since their destruction seriously hampers the defense's effectiveness, target tracking radars and control centers are the most lucrative targets.

16.5.2.4 Additional ECM Considerations. The ability of a threat system to successfully detect, locate, identify, and track an airborne target is critical to system employment. Features that reduce the target signature are therefore extremely important. There are several observable or detachable parameters utilized by threat systems for target detection:

1. Electromagnetic reflection
2. Thermal or infrared radiation
3. Optical signature
4. Acoustic signature.

The method of detection used is typically a function of the sophistication of the threat system, as indicated in Figure 16-8.

16.5.2.4.1 Radar Signature Considerations. Ground-based and airborne radar systems are used to provide a wide variety of weapon system functions, including search, acquisition, tracking, fire control, guidance, and fuzing. All of these systems employ the principle of radio frequency. Electromagnetic energy that is emitted in a specific frequency band from a transmitter is reflected from a target and then intercepted by a receiver. The transmitted and received signals are compared, and a target location and velocity are obtained. The parameter that describes the strength of radar signals reflected from a target is called the radar cross-section (RCS). It is a function of the size and shape

THREAT SYSTEM	TYPICAL DETECTION METHODS
Small Arms thru 14.5 mm	Visual, aural
Antiaircraft guns 20 mm thru 100 mm	Visual, aural, radar
Air-to-air guns (AAG)	Visual, Radar
Air-to-air rockets (AAR)	Visual, radar
Air-to-air missiles (AAM)	Radar, IR
Surface-to-air missiles (SAM)	Radar, IR

Figure 16-8. Target Detection Cues

of the target, the electromagnetic properties (permittivity, permeability, and conductivity) of the materials from which it is made, the radar signal frequency, and the orientation, or aspect, of the target with respect to the radar. Other types of targets exhibit RCS levels considerably larger than their physical cross-sections because of a focusing effect of the reflected energy in the direction of the receiver.

The size of the target RCS impacts the performance of radar in several ways, but the most important effect is the establishment of a maximum range limitation. A target with a large RCS can be readily detectable even at long ranges. If the target RCS is small, it is less detectable.

The two parameters that determine an object's RCS are geometry (size and shape) and electromagnetic properties. Materials with very high conductivity are the strongest reflectors. In consideration of the geometry, shape is usually the more significant geometric determinant of RCS. Energy incident on a flat metallic surface such as a wing or fuselage side will tend to be reflected away from the source for all angles of incidence except the angle perpendicular to the surface. Only small radar echoes thus result. Metallic, cavity-shaped structures, on the other hand, tend to behave like reflectors which reflect much incident energy back toward the source. Structures such as engine inlets and exhaust systems tend to be major RCS contributors.

a. Radar Resolution Cell (RRC). Radar distinguishes target location by breaking the scanned airspace into box-like cells called resolution cells. A resolution cell is determined by the horizontal and vertical beamwidth and the pulse width of a given radar. Two or more targets within a single resolution cell may be returned as a single target, indistinguishable by the radar operator.

You can calculate the rough dimensions of any radar RRC by using the following formulas:

$$\text{Range (ft)} = \frac{\text{Pulse Width}}{12.35} \times 6{,}000$$

Azimuth or elevation = 104.7 X range X beamwidth

b. Maximum Radar Range (Unambiguous). Intelligence analysts, when determining the maximum range of a radar, will use the capability of the system to detect a one square meter target. Maximum radar range is a function of the effective radiated power (ERP). A more useful concept for the tactical aviator is maximum unambiguous radar range. In a typical pulsed radar, echo returns from one pulse to the next are used to determine range of the target aircraft. The time available between pulses is the pulse repetition interval (PRI). It logically follows that there is only so much time available to measure echo returns for one pulse before the next pulse must be transmitted to repeat the process and update the measurements. This defines the maximum unambiguous range. This means that there are no ambiguous returns resulting from pulses being emitted before the first pulse can go out and return. Use the following formula for estimating R_{max}:

$$R_{max}\text{ (nm)} = \frac{\text{PRI (in µsec.)}}{12.35}$$

c. Minimum Radar Range. An echo cannot be processed or measured before the complete pulse is transmitted. The time required to complete a pulse is called the pulse width (PW).

Thus:

$$R_{min}\text{ (NM)} = \frac{\text{PW (in µsec.)}}{12.35}$$

d. Altitude. There are two physical phenomena associated with radars and the altitude of target aircraft. One centers around the curvature of the Earth and radar horizons. The other is the result of multiple return echoes generated by flying low to the ground.

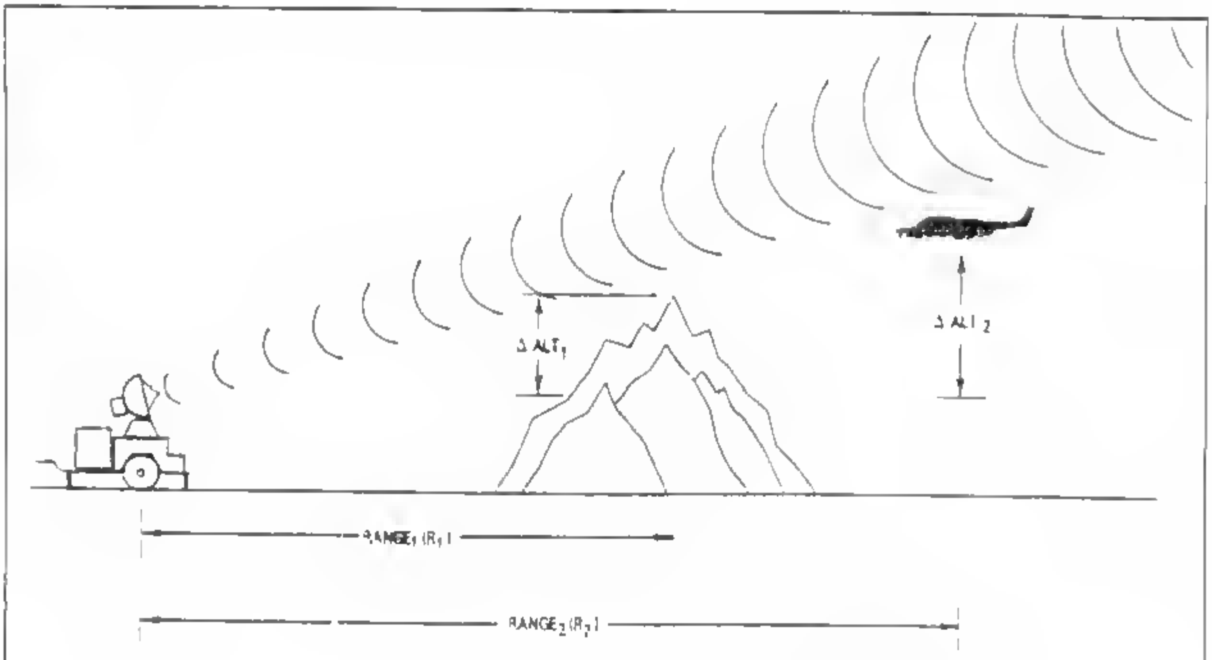
e. Radar Horizon — barring terrain or large man-made obstructions, for every radar antenna height and target aircraft ingress altitude there is a mathematically predictable radar horizon range (Figure 16-9). The formula is:

$$R = 1.23\left(\sqrt{H} + \sqrt{h}\right)$$

Where:

H = antenna height

h = aircraft altitude



$$\frac{\Delta ALT_1}{R_1} = \frac{\Delta ALT_2}{R_2}$$ SOLVE FOR THE DESIRED QUANTITY

Figure 16-9. Radar Horizon Range

Note

> The above equation yields accurate results from 70° north latitude to 70° south latitude.

As previously mentioned, this assumes no obstructions or terrain to mask behind. In the event terrain can be utilized to prevent radar line of sight (LOS) until somewhere within the radar horizon range, the unmask range at various altitudes may be predicted.

If attempting to establish an altitude (MSL) to fly at a given range, remember to add the Δ alt_2 to antenna height plus elevation of the radar sight (Figure 16-10).

f. Minimum Detection Altitude. As a basic pulse TTR is forced to place its beam closer to the ground, its ability to accurately track will be affected. This ambiguity is caused by two near simultaneous echo returns: one by the target aircraft, the other by a ground return. See Figure 16-11.

This phenomenonon occurs when the target aircraft is closer to the ground than one-half of the beam width (feet) at the range in question. In order to predict, use the following formula:

$$\frac{\text{Altitude} + \text{BW X Range X 100}}{2}$$

16.5.2.4.2 Infrared Signature Considerations. All aircraft emit and reflect IR energy. The amount of IR radiation emitted by an aircraft is strongly dependent on the surface temperature. The dominant IR contributors over the aft hemisphere of the aircraft are the hot engine exhaust surfaces. Radiation from the engine exhaust gases and from the airframe surfaces are the principal contributors over side and frontal aircraft sections. The sides and bottom of an aircraft appear as significant IR sources by reflecting radiation from the sun and Earth. Reflective radiation during daylight operations is very strong and may approach the intensity of engine surface emissions.

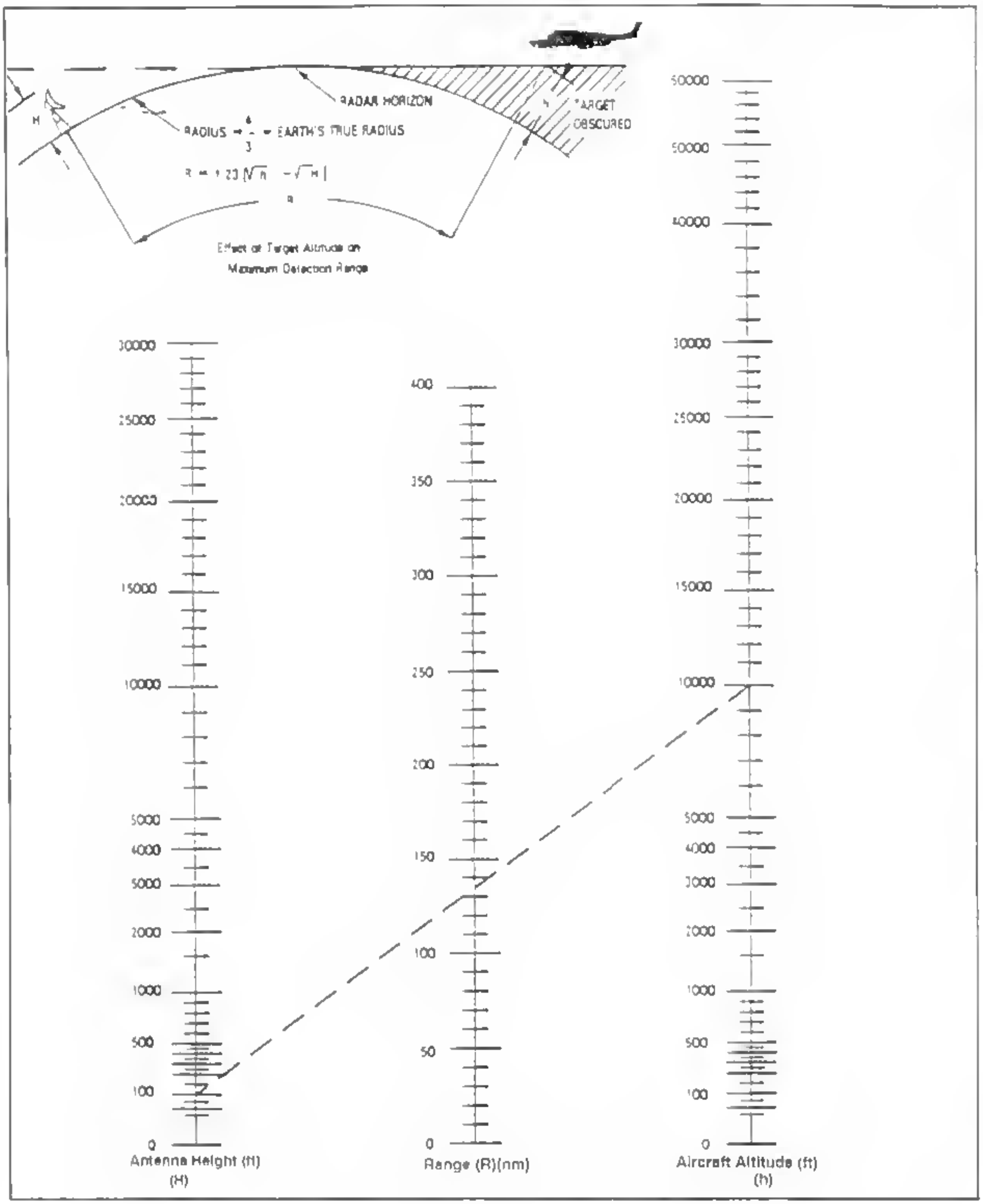


Figure 16-10. Radar Horizon Nomograph

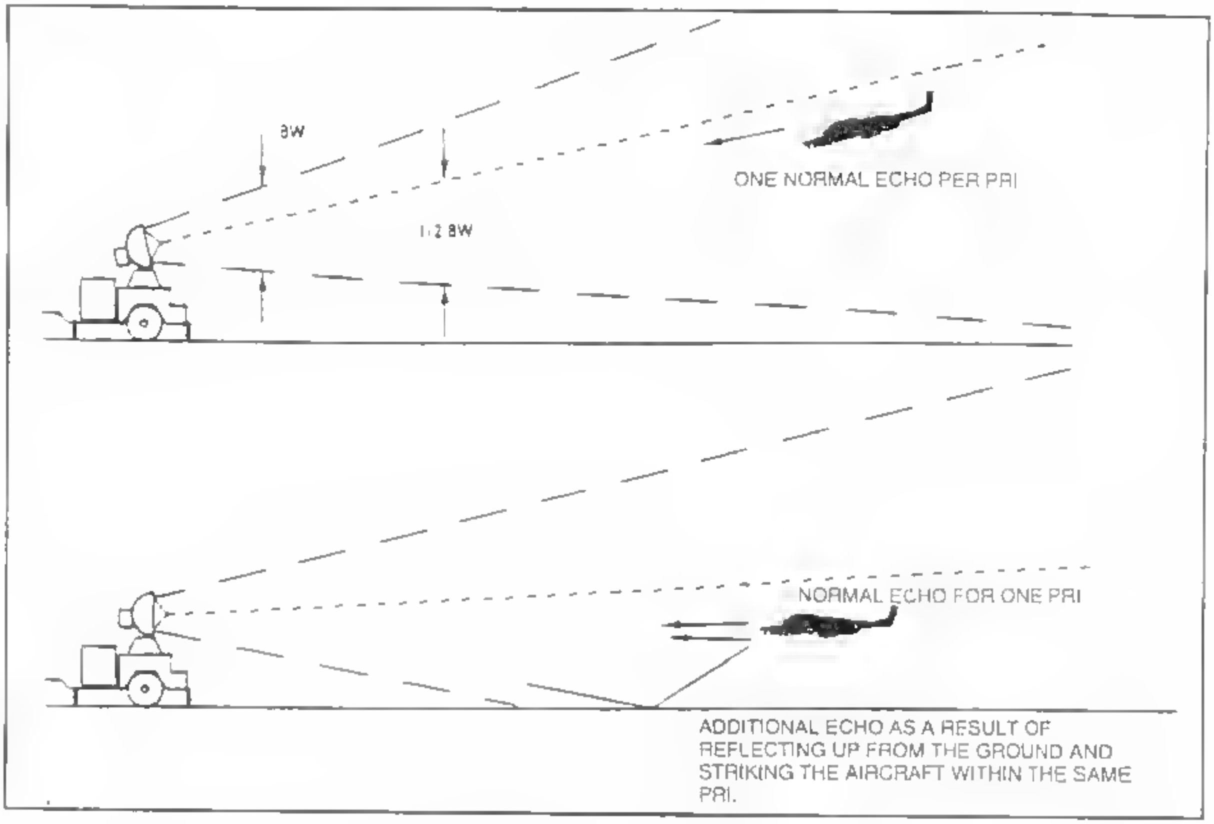


Figure 16-11. Minimum Detection Altitude

Infrared suppression techniques reduce the level of infrared radiation and degrade threat capabilities by reducing the size or intensity of IR radiant zones on the aircraft. This signature reduction can be accomplished in many ways.

Engine IR emissions can be reduced by cooling engine exhaust system components with cooling air pumped by external blowers or ejectors in the case of turboshaft engines. Engine exhaust system components that may be cooled are the exhaust frame centerbody, flame-holders, tailpipe, and nozzle walls. The cooling air is generally applied to the surface throughout cooling slots that combine impingement and convective cooling.

Cooled shields are often used to block IR radiation from components that remain hot, such as turbine blades. Another method of shielding turbine blades from view is to incorporate a turn in the exhaust duct. Further IR radiation reduction may be accomplished by coating such surfaces with IR radiation absorbent materials.

Low IR paint is used to lessen the signature of broad reflective IR sources, such as the fuselage.

Infrared energy is a band of electromagnetic radiation possessing wavelengths longer than the visible spectrum and shorter than radar waves. The unit most commonly used to discuss wavelengths of IR radiation is the micron (equivalent to 1,000 nanometers or 10^{-6} meters). A 1-micron wavelength corresponds to a radio frequency of 10^5 GHz.

The IR band is sometimes broken down into three regions: *near* IR (closest to visible light), *mid* IR (where most IR missiles operate), and *far* IR (where IR imaging devices operate). For a further description of IR bands, refer to NWP 55-9-ASH, Volume II. Bandwidth describes the range of wavelengths or frequencies over which IR energy is radiated.

Materials with temperatures above absolute zero (0° K or -273° C) radiate electromagnetic energy over a broad spectrum, including the IR band. The intensity and spectrum of this radiation are dependent on the temperature of the material. If a material is at absolute zero, its molecular vibrations cease and it stops radiating. As a material's temperature rises, its spectrum shifts toward shorter wavelengths, and it radiates with greater intensity; for example, the curve representing a hot jet tailpipe lies between 3 and 5 microns.

Infrared detection is passive; it does not rely on active means such as bouncing or reflecting energy off a target to be detected. A missile designed to detect a jet tailpipe would have a passive seeker head operating in the 3- to 5-micron range.

Another means of passive detection in the IR seekers is to have the seeker head detect the exhaust plume instead of the tailpipe. By selecting this detection method, it is possible to give a missile a greater aspect angle. For example, the hot sections of an engine can be detected only from ±30° of the tail. However, the plume emanating from a jet engine can be detected easily from any aspect except head-on. By increasing the sensitivity of the material used to detect IR sources (usually obtained by cooling IR detection materials), an IR missile can be given an all-aspect detection capability. Plume detectors in IR seekers are very specific and either seek the IR radiation of heated CO_2 or water vapor (H_2O) with 3-micron and 4.2-micron wavelengths, respectively. Supersonic targets also radiate a very specific IR energy off the leading edge of the wing usually above 4 microns. A seeker designed to detect this IR source has a head-on attack capability.

16.5.2.4.3 Visual Signature Considerations. The majority of combat aircraft lost in Southeast Asia were hit by projectiles from optically directed weapons. In many cases, the enemy aired a barrage in the direction of aircraft visual signatures other than the aircraft itself. This was especially true for fixed-wing jets emitting engine smoke trails, contrails, or at night, engine exhaust glow. Visual signatures can be reduced by limiting engine smoke emissions, reflective glint, aircraft lighting, and background contrast.

Helicopter rotor heads can be significant sources of reflected light. Consideration should be given to coatings that subdue such reflective surfaces.

Camouflage is an effective means of reducing daytime detection by minimizing the visual contrast of the aircraft with its background. Nighttime combat operations are cases where the aircraft interior and exterior lighting systems must be considered as major sources of visual clues to enemy forces. Exterior lights should be masked to the greatest degree practicable. The capability of unused anticollision light installations to reflect moonlight or other light sources should be considered to minimize such occurrences. Interior instrument lighting systems must be considered sources of light potentially detectable by the enemy. Care should be exercised to minimize the direction and intensity of instrument lighting for combat missions and to minimize the interior reflective surfaces of the cockpit.

a. Electro-Optics. While electro-optics (E-O) is used to describe the generic science using the optical spectrum, it is also used to describe visual devices that are augmented by electrical means. E-O systems are normally used in conjunction with radar to improve the total weapon system capability. The optical system not only gives the weapon system an additional dimension but also enhances the potential of the radar mode. Most long-range optical devices inherently have narrow fields of view because of physical properties. A narrow field of view limits a system's usefulness as a detection acquisition device; it normally requires cuing from some external source. This cuing source is normally radar and is one of the primary reasons these two systems have been mated. If countermeasure tactics, such as jamming or chaff, are successful in degrading the radar ability to engage a hostile aircraft, the operator need only switch modes of operation and track the intruder optically.

Furthermore, the capability of most present-generation radar is degraded as the tracking angle between the antenna and ground gets smaller. Ground clutter increases the number of targets on the radar operator's scope, creating confusion. Moving target indicators and other similar circuits have been developed to overcome this deficiency, but they are not totally effective. As the radar presentation deteriorates because of low tracking angles, the optical system operator can assume the tracking duties. This dual capability gives the weapon system greater flexibility and severely complicates the evasion problem as both the radar and optical threats must be countered simultaneously. Engineers have successfully integrated the standard television system with a radar tracking system. A TV camera modified with either a zoom-type or individual

long- and close-range lens is physically mounted to the radar antenna assembly (Figure 16-12).

The azimuth and elevation inputs from the TV camera and the radar are routed to a common computer that processes the data and computes the firing solution. Because the TV camera and radar antenna are comounted, the antenna positioning inputs are the same regardless of which system is actively tracking. This common reference also facilitates the cuing function necessary to effectively employ a TV system. The standard TV system is limited to daylight-only operations because of its physical properties. Low-level TV is one of the image intensifier systems actively used in the military community. Its integration is very similar to that described in the TV discussion (Figure 19-12). The perfection of low-light-level TV gives a weapon system an excellent night optical capability.

Another application of E-O occurs in missile seekers. Since visible light varies in frequency (color), it is possible to cause the seeker to sense variance in frequency and keep the axis of the lens centered on one frequency. This technique is referred to as *contrast tracking*. This technique simply measures contrast (frequency difference) and tracks that visible frequency difference. The seeker may also be designed to track both IR wavelengths and visible light (or near visible light), switching back and forth to whichever source presents the best tracking solution. This technique is referred to as *two-channel* or *two-color contrast tracking*. When E-O techniques are used in missile seekers, the seeker becomes the weapon tracking system. In this case the operator slews the launcher to a predetermined azimuth, locates the target visually, and *locks* the missile seeker onto the target before launch. Independently, E-O systems cannot determine range. Accordingly, E-O trackers are usually aided by a range-only range (ROR). It is usually a very simple high frequency FM-CW system.

Daytime tracking in the visible light is possible with TV-type contrast trackers with very high precision. Because the precision is usually obtained with magnification, the target is readily identified. Identification can be achieved at ranges up to 20 kilometers.

16.5.2.4.4 Aural Signature Considerations. Aircraft can be detected by their aural signature, often as a result of engine noise. Though other battlefield noise may mask such target signatures, helicopter rotors can contribute markedly to the acoustic signatures of rotary wing aircraft.

16.5.2.4.5 Electronic Counter-Countermeasures (ECCM). ECCM is the division of electronic warfare involving actions taken to ensure effective use of electromagnetic spectrum despite the enemy's use of EW. Electronic counter-countermeasures are used in radar missile systems to reduce the system's vulnerability to jamming. This is done by preventing receiver overload, using signal discrimination techniques to distinguish between radar and jamming signals, using jamming signals to aid in target engagement, and discriminating true returns in range, velocity, or angle to minimize deception ECM capabilities.

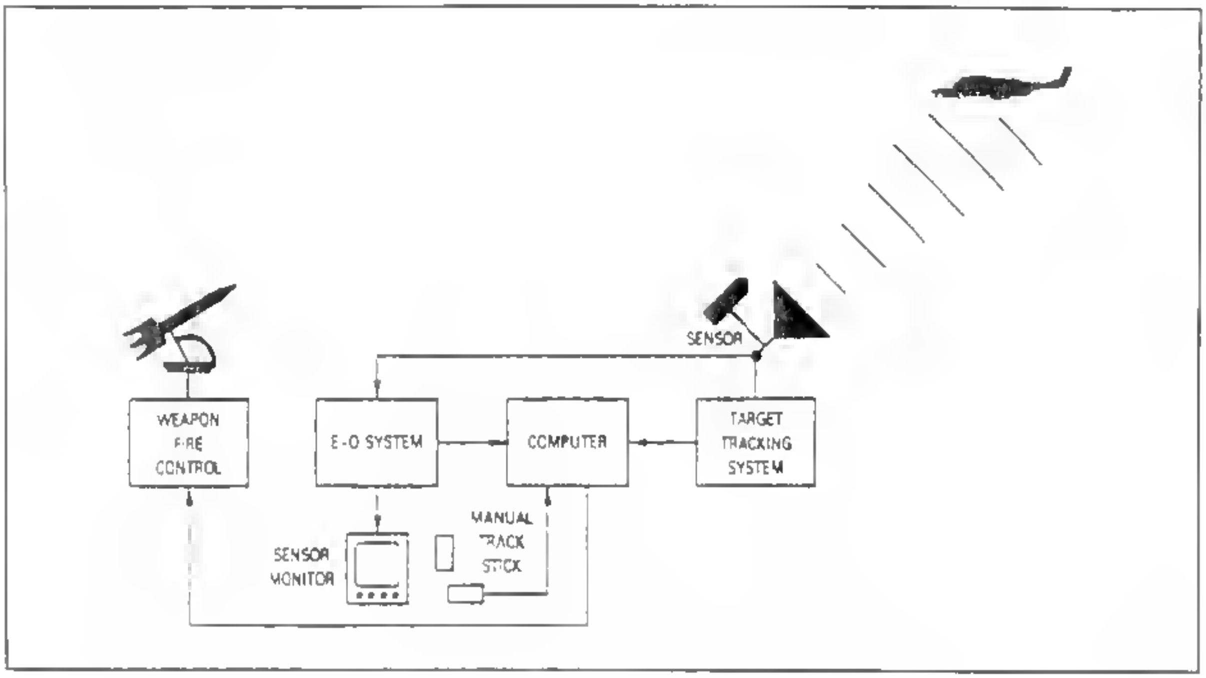


Figure 16-12. Television/Radar Tracking System

CHAPTER 17

Electronic Warfare Equipment

17.1 INTRODUCTION

This chapter is an unclassified presentation of the OV-10 EW equipment. It will cover a description, the operating instructions and information on the AN/APR-39(V)1 radar warning receiver, AN/ALE-39 countermeasures dispensing set, and the AN/ALQ-144 infrared jammer. Mention will also be made of advanced EW equipment items.

17.2 ELECTRONIC WARFARE EQUIPMENT

The electronic warfare equipment is designed to make the OV-10 more survivable in the expected threat environment. The EW equipment has a definite interaction, whether or not the equipment is physically or electrically connected. The interaction of the equipment is directly related to the action and employment of the aircraft and its equipment. Tactical employment still depends on sound tactics to survive in a threat environment but will not protect the OV-10 if it is not employed in a sound tactical manner. The best countermeasure in any threat environment is denial of acquisition to the enemy, and this is best accomplished by terrain flight profiles.

17.3 AN/APR-39(V)1 RADAR WARNING RECEIVER

The APR-39 provides the aircrew with bearing, identity, and mode of operation of radars that operate in E, F, G, H, I, and J bands and portions of C and D bands for radar associated signals. A CRT displays strobes and auto-proportioned PRF of signals plus alarm tones.

17.3.1 Control and Indicators. The cockpit control unit has an ON/OFF switch for operation of the equipment, a self-test switch that activates the CRT test display and audio test tone, a discriminator switch to reduce the system sensitivity (discriminator should not be used in a tactical situation), and an audio volume control knob to adjust headset PRF volume. The cockpit display CRT has a brilliance adjustment knob to adjust intensity for daylight down to night vision goggle intensity. A polarized filter for day-night operations adjusts the color of the strobes from white to red. An MA light is located at the 10 o'clock position on the CRT.

17.3.2 Equipment. There are four spiral antennas mounted on the left and right front of the nose and on the left and right rear of the aircraft. A radar receiver mounted in the nose electrically connects the two front antennas to the comparator; a similar radar receiver is mounted in the tailboom. A blade antenna, mounted on the belly of the aircraft provides C- and D-band radar information to the comparator to activate the MA light on the CRT. The comparator provides video signals to the CRT and audio signals to the crew ICS (Figure 17-1).

17.3.3 Control and Functions. Figures 17-2 and 17-3 describe the functions of the controls for both the cockpit control unit and the radar signal indicators.

17.3.4 Operating Procedures

17.3.4.1 Turn On Procedure. The procedure for turning on the equipment follows Figure 17-2.

CAUTION

To prevent damage to the receiver detector crystals, assure that the AN/APR-39(V)1 antennas are at least 60 yards from active ground-based radar antennas or 6 yards from active airborne radar antennas. Allow an extra margin for new, unusual, or high-powered emitters.

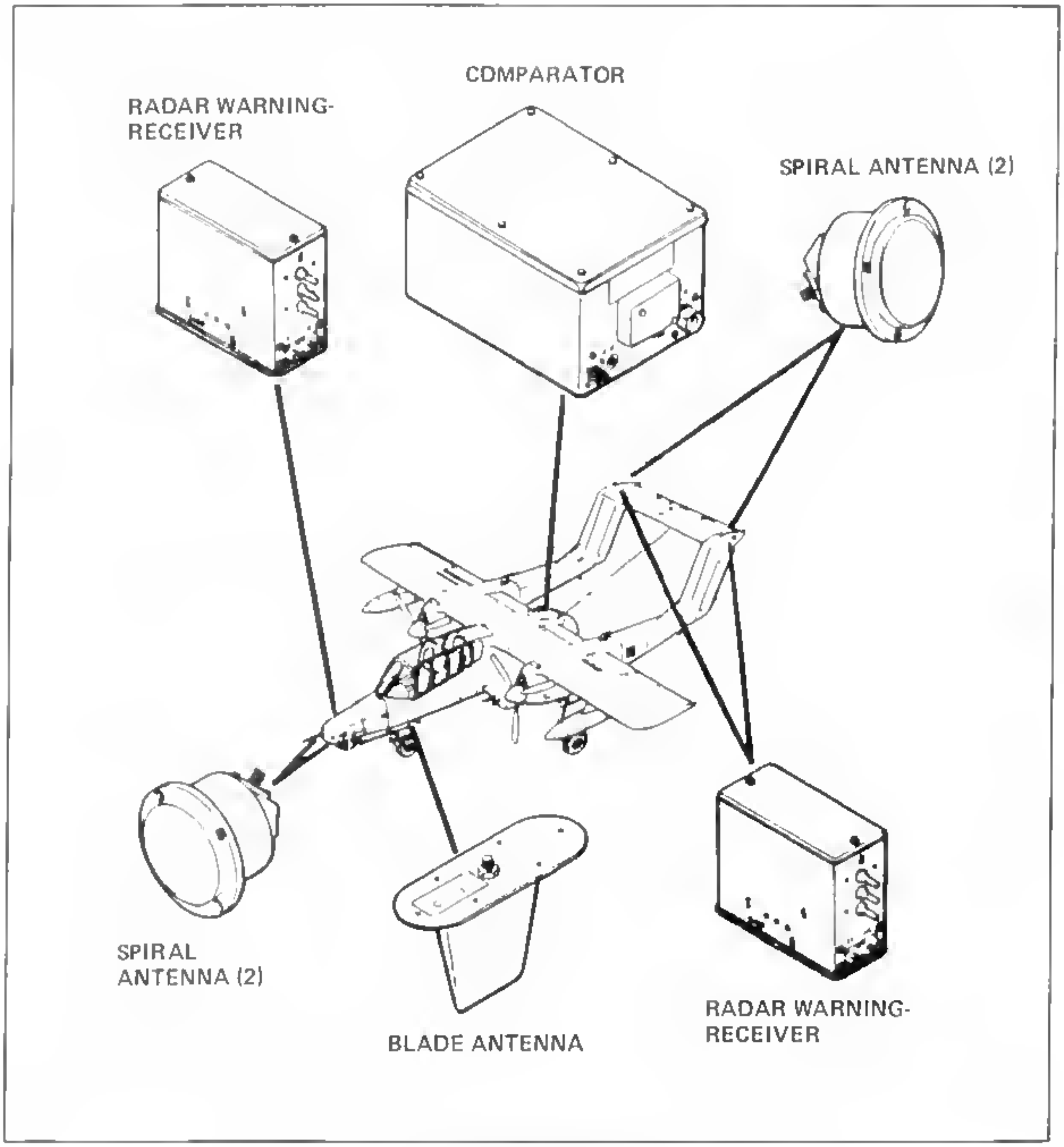


Figure 17-1. AN/APR-39(V)1 Radar Warning Receiver Components

CONTROL NAME	DESCRIPTION	FUNCTION
PWR	TWO POSITION TOGGLE SWITCH	CONTROLS APPLICATION OF AIRCRAFT +28 VDC TO THE AN/APR-39(V)1 a. ON POSITION APPLIES OPERATING POWER. THE AN/APR-39(V)1 IS FULLY OPERATIONAL 1 MINUTE AFTER SWITCH IS TURNED ON. b. OFF POSITION REMOVES OPERATIONAL POWER FROM AN/APR-39(V)1.
SELF-TEST	PUSHBUTTON SWITCH (SPRING LOADED).	WHEN DEPRESSED, ENERGIZES THE SELF-TEST FUNCTION
DSCRM	TWO-POSITION TOGGLE SWITCH	SELECTS AN/APR-39(V)1 MODE OF OPERATION. a. ON (UP POSITION) ACTIVATES THE DISCRIMINATOR CIRCUIT. b. OFF (DOWN POSITION) DEACTIVATES THE DISCRIMINATOR CIRCUIT.
AUDIO	POTENTIOMETER	CONTROLS THE LEVEL OF THE AUDIO OUTPUT TO THE AIRCRAFT INTERPHONE CONTROL SYSTEM.

Figure 17-2. Cockpit Control Unit Functions

1. Check to see that the aircraft 28-vdc bus for the AN/APR-39(V)1 equipment in the aircraft is turned on. (Refer to applicable electronics configuration manual for the particular aircraft.)

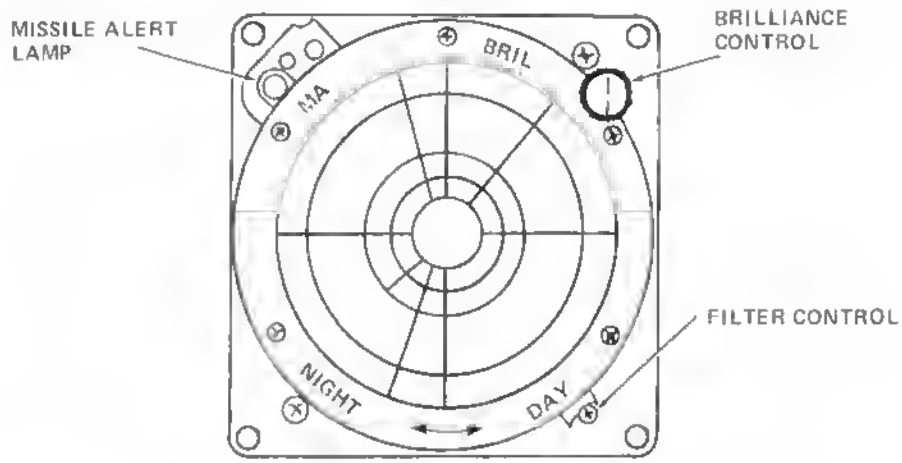
2. Set the PWR switch (Figure 17-2) to ON, and allow a minimum of 30 seconds for the equipment to become fully operational.

3. Depress and hold the SELF TEST switch; adjust the BRIL and FILTER controls for the desired CRT display brilliance and color (maximum red for NIGHT). Adjust the AUDIO to the desired output level; release the SELF TEST switch.

4. Manipulate the DSCRM switch in accordance with mission requirements.

Note

The discrimination switch should be in the OFF position in a tactical situation.



NAME	DESCRIPTION	FUNCTION
DIRECTION DISPLAY	CRT DISPLAY	SHOWS A LINE OF BEARING RADIAL STROBE FOR EACH PROCESSED EMITTER SIGNAL.
MA INDICATOR	LAMP	FLASHES ON AND OFF TO INDICATE TIME CORRELATION BETWEEN THE MISSILE GUIDANCE AND ASSOCIATED TRACKING RADARS (SAM RADAR COMPLEX).
BRIL CONTROL	POTENTIOMETER	VARIES THE BRILLIANCE OF THE CRT DISPLAY; USED IN CONJUNCTION WITH THE FILTER CONTROL TO PRODUCE A HIGHLY VISIBLE, UNOBTRUSIVE DISPLAY UNDER MOST LIGHTING CONDITIONS.
FILTER CONTROL		VARIES THE DENSITY OF THE RED POLARIZING FACE-PLATE FILTER (PRIMARILY FOR DAY OR NIGHT OPERATION).

Figure 17-3. Radar Signal Indicator Control and Display Functions

17.3.4.2 Operation Modes. The equipment may be operated in either the discriminator off or on mode.

CAUTION

Display strobe lengths indicate only received signal amplitude. Since many variables can affect the atmospheric attenuation of the signals, strobe length should not be interpreted as being directly indicative of distance to the emitter.

17.3.4.2.1 Discriminator Off Mode. When operated in the discriminator off mode, the DSCRM switch is placed in the OFF position. In this mode all highband received signals with an amplitude greater than the predetermined threshold level are displayed on the CRT and an audio signal, representative of the combined amplitudes and pulse repetition frequencies (PRFs), is present at the headset. The displays indicate the total radar environment in which the aircraft is operating. Each radial strobe on the CRT is a line of bearing to an

active emitter. When a SAM radar complex becomes a threat to the aircraft (lowband signals correlated with highband signals), the unique alarm audio is superimposed on the PRF audio signal and the MA lamp and associated strobe start flashing. Lengths of strobes and audio levels depend on the relative strength of the intercepted signals.

Note

> In this mode, received lowband signals that are not correlated with a wideband intercept will cause the MA lamp to flash and an alarm audio will be present.

17.3.4.2.2 Discriminator On Mode. When operating in the discriminator on mode, the DSCRM switch is placed in the ON position. In this mode, signals are processed to determine their conformance to certain threat-associated criteria:

1. The signal level must be greater than the minimum threshold level.

2. Pulse width must be less than the maximum pulse width.

3. PRF must be greater than the minimum pulses per second (PPS).

4. The pulse train must exist with not less than minimum pulse train persistence.

5. The CRT display is divided into eight sectors. Strobes are displayed only in those sectors in which signals meeting all threat criteria are present. This reduces display clutter by eliminating low-level and width-pulse-width signals and by selective sector display. Intercepts that meet these requirements are displayed as described previously.

Note

> In this mode, uncorrelated lowband signals will not give any indication.

17.3.4.3 Self-Test. The self-test confidence checks the AN/APR-39(V)1 circuits except:

1. Antennas

2. High-pass filters and detectors in the highband receivers

3. Band-pass filter and detector in the lowband receiver section

4. Analysis signal commutator

5. Highband and lowband blanking circuits.

Figure 17-4 lists the procedure for the self-test.

17.3.4.4 Shutdown. The APR-39 is shut down by placing the PWR switch in the OFF position.

17.3.5 Audio and Visual Signals. Figures 17-5 through 17-8 list AN/APR-39(V)1 audio and visual signals for various Soviet-built weapon system radars.

The APR-39 will also receive and display free-world radars and both Soviet and non-Soviet airborne radars. No listing of visual or audio signals of these radars is currently available.

17.4 AN/ALE-39 COUNTERMEASURES DISPENSING SET (AFC 82)

17.4.1 Description. The AN/ALE-39 (Figure 17-9) is installed and is used to dispense countermeasures materials (metallic chaff, flares, and jammers) aft of the aircraft. The ejected countermeasures materials deceive enemy radars and infrared sensors and jam communications frequencies, which enable the aircraft to evade air-to-air and surface-to-air attacks. Each dispenser has 30 cylindrical discharge tubes, electrically partitioned into sections of 10 and 20 discharge tubes. The dispenser module sections are identified as L10 (left 10), L20 (left 20), R10 (right 10), and R20 (right 20) to distinguish payload locations and controlling circuits. The cartridges containing the countermeasures materials are carried in the discharge tubes of the two dispensers. After the dispensers are loaded, the pilot sets the programmer LOAD switches to indicate which type of load is in each of the four sections. The countermeasures materials are ejected from the dispenser tubes by electrical signals controlled by either aircrew. The programmer search and fire circuitry automatically senses the location of the selected type of payload in the dispensing sections. If the desired type of payload is not loaded or has been expended from one section, the system cascades to the next loaded dispenser section from which the dispensing sequence is completed.

1 Apply power to AN/APR 39 (see applicable aircraft manual).	Control unit panel lamps come on
Note In well-lighted areas it may be necessary to shade the panel to determine whether panel is lighted.	
2 Set control unit DSCRM switch OFF, PWR switch ON, and wait 1 minute for warm-up. Monitor indicator CRT and audio, and press and hold SELF-TEST	a. Fwd and aft strobes appear, extending to approximately the third circle on the indicator graticule, a 2.5 kHz (approximately) PRF audio present immediately. b. Within approximately 6 seconds, alarm audio present and the MA lamp starts flashing.
3 Rotate indicator BRIL control cw and ccw	Indicator strobes brighten (cw) and dim as control is rotated. (Set control for desired brightness level.)
4 Rotate control unit AUDIO control between max ccw and max cw.	Audios not audible at max ccw and clearly audible at max cw.
5 Release SELF-TEST	All indications cease.
6 Set DSCRM to ON. Press and hold SELF TEST.	a. Within approximately 4 seconds a fwd or aft strobe (either may appear first) and 1.2 kHz (approximately) PRF audio present.
Note Occasionally during the period between pressing SELF TEST and appearance of the first strobe, a distorted dot on the indicator and intermittent audio will be present. This is not a fault indication.	
	b. Within approximately 6 seconds, the other strobe will appear, and PRF audio frequency will double. c. Several seconds later, alarm audio present, and MA lamp starts flashing.
7 Release SELF-TEST	All indications cease
8 Set control unit PWR switch OFF	

Figure 17-4. Self-Test Procedure

Manual (single) dispensing or multiple programmed dispensing sequences of countermeasures materials can be selected on the pilot's control panel and dispensing initiated by either crew by depressing the INITIATE switch. Manual dispensing can be performed during a programmed dispensing sequence

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
SA-2 FAN SONG RADAR	Audio	Similar to rattlesnake or Geiger counter	None	Similar to rattlesnake or Geiger counter	Activated (low frequency pulsating tone)
	Visual	Rapidly flickering strobe	None	Rapidly flickering strobe	Activated (rapidly flickering strobe)

Figure 17-5. FAN SONG Radar

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
SA-3 LOW BLOW RADAR	Audio	Similar to chirping cricket	Same as Search	Medium to high pitched tone	Activated (medium frequency pulsating tone)
	Visual	Rapidly pulsating strobe	Same as Search	Solid strobe	Activated (pulsating strobe)
SA-4 PAT HAND RADAR	Audio	Low frequency tone	Chirping sound	Steady low frequency tone	Activated (steady low frequency tone)
	Visual	Intermittent strobe	Same as Search	Steady strobe	Activated (steady strobe)
SA-6 STRAIGHT FLUSH RADAR	Audio	Low pitched audio with beep every 3 to 4 seconds	Same as Search but increase in tempo for audio and visual	Continuous low pitched tone	None
	Visual	Strobe flash every 3 to 4 seconds		Straight, steady strobe	None

Figure 17-6. LOW BLOW, PAT HAND, and STRAIGHT FLUSH Radars

without disrupting the program. Flare salvo dispensing can also be initiated by placing the POWER/FLARE SALVO switch on the pilot's control panel to the FLARE SALVO position. All remaining flares, regardless of loaded location, are dispensed in a rapid-fire sequence.

CAUTION

Flares located in subsections that are not identified in the programmer control panel as containing flares (f) will not dispense when the power/flare salvo switch is initiated.

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
SA 8 LANDROLL RADAR	Audio	Similar to electronic TV ping pong game	Same as Search	Medium to high pitched tone	None
	Visual	Intermittent STROBE	Same as Search	Steady strobe display	None
ZSU 23-4 GUNDISH RADAR	Audio	Steady, high pitched tone	Frequently modulating (similar to hammer striking chisel)	Steady high pitched tone	None
	Visual	Intermittent, wide bright strobe	Rapidly blinking strobe	Wide, bright steady strobe	None

Figure 17-7. LAND ROLL and GUNDISH Radars

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
S 60 FLAPWHEEL RADAR	Audio	Intermittent audio beep (5 to 6 sec)	Same as Search but increase in tempo	Steady low pitched tone	None
	Visual	Intermittent strobe (5 to 6 sec)	Grows in length	Steady strobe	None

Figure 17-8. FLAP WHEEL Radar

Programmed dispensing routines for chaff, flares, and jammers are set into the programmer, and LOAD switches set to indicate which type of load is in each of the dispenser sections. Programmer controls for the programmed dispensing of countermeasures materials can be set to control the number of bursts (single firings) and the time lapse between bursts. In addition to burst quantity and interval control, the chaff programmed payload dispensing control includes the number of chaff salvos and the time lapse between chaff salvos in a programmed sequence.

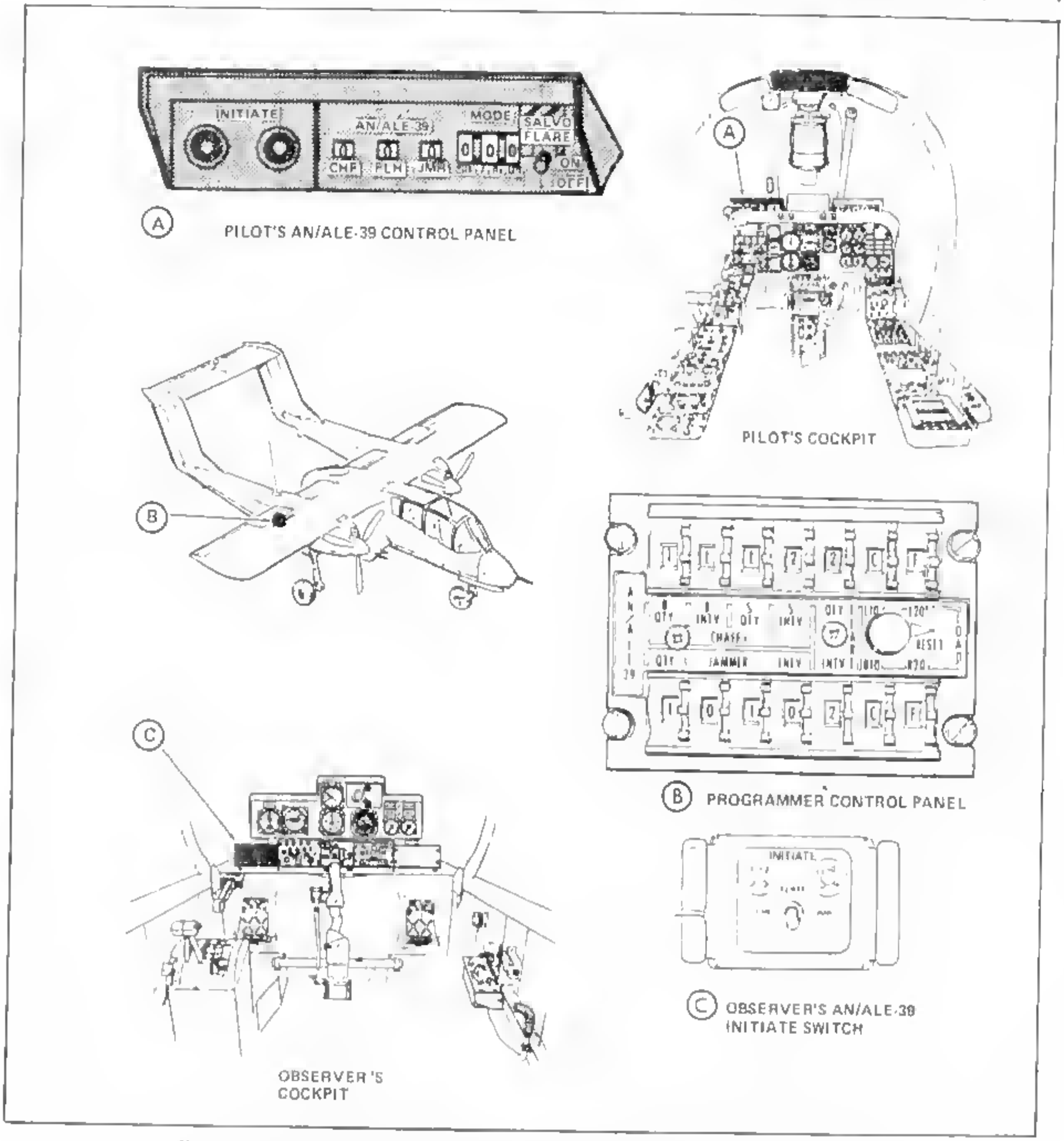


Figure 17-9. AN/ALE-39 Countermeasures Dispensing Set Control and Indicators (For Aircraft With AFC 82 Installed) (Sheet 1 of 2)

17.4.2 Controls and Indicators. The ALE-39 system controls consist of a programmer control panel, a pilot control panel, and initiate switches in each cockpit (Figure 17-9.) The system is in the ready status when the dispenser safety pin has been removed, and the control panel selector switch is ON. A fire command can be initiated by either aircrew for either manual or automatic dispense sequences.

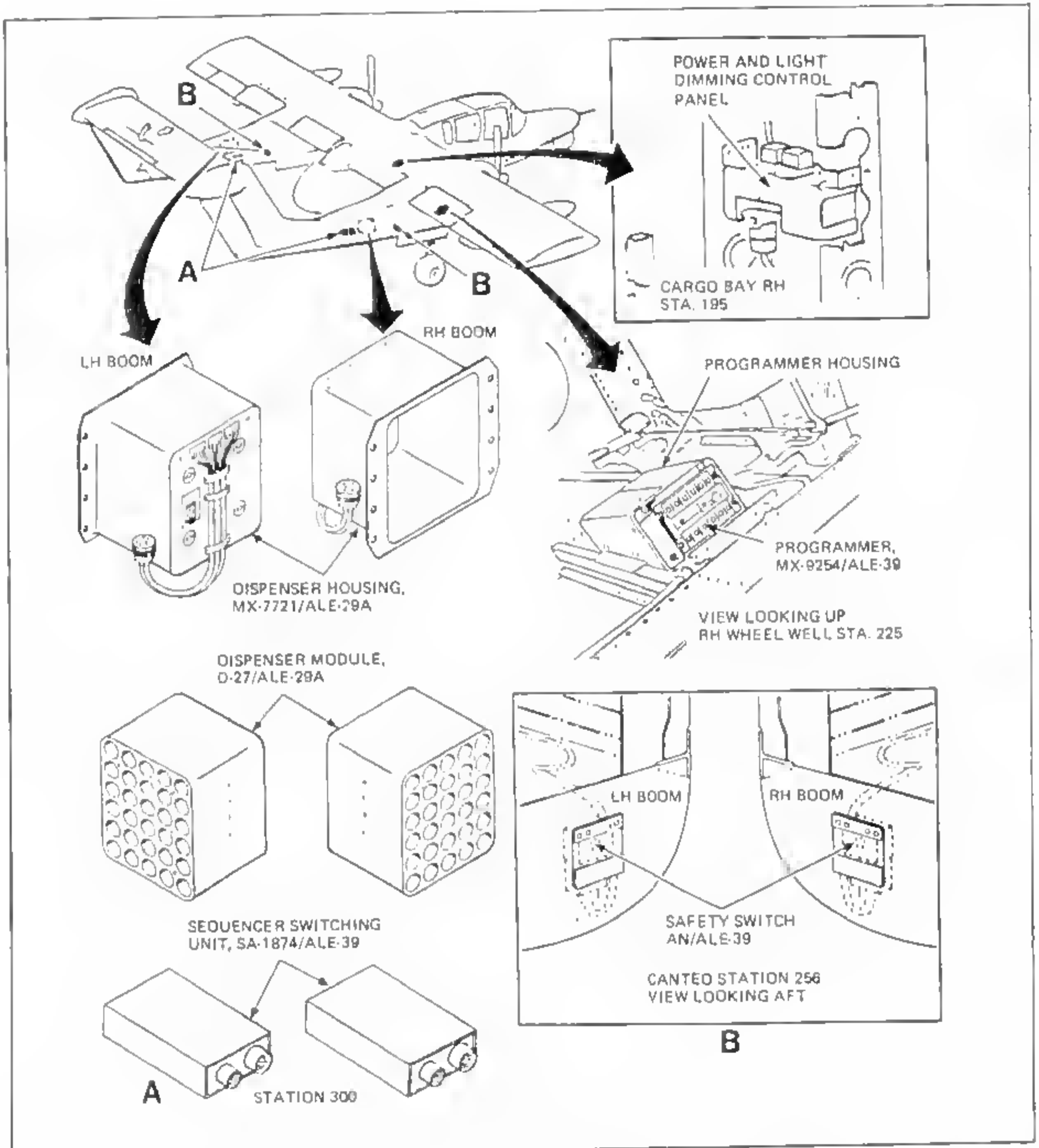


Figure 17-9. AN/ALE-39 Countermeasures Dispensing Set Control and Indicators (For Aircraft With AFC 82 Installed) (Sheet 2 of 2)

17.4.3 Programming Selections

17.4.3.1 POWER/FLARE SALVO Switch. A POWER/FLARE SALVO lever lock toggle switch (Figure 17-10) has ON, OFF, and FLARE SALVO positions and is used to control primary 28-vdc power to the AN/ALE-39 programmer and to initiate the programmer flare salvo sequence.

17.4.3.2 Mode Selector Control Switches. Three rotary selector switches (Figure 17-10) are provided for selection of chaff (CHF), flare (FLR), and jammer (JMR) dispensing modes. The chaff and jammer mode selector switches have four positions: O (off), S (single), P (program), and R (RWR). The flare mode selector switch has eight positions: O (off), S (single), M (multiple), O (off), P (program), G (group), O (off), and R (RWR). These positions function as follows:

POSITION	FUNCTION
O (off)	Initiation of dispensing is not possible.
S (single)	Causes a single dispense command to the programmer for each activation of the dispense INITIATE switch.
P (program)	Causes a programmed dispense command to be sent to the programmer for each activation of the dispense INITIATE switch.
R (RWR)	Causes a single dispense command to be sent to the programmer for each activation of the dispense INITIATE switch.
M (multiple)	A command to the programmer to cause it to dispense flare payloads (one per available subsection) in parallel, if available, and is initiated by activation of the flare dispense INITIATE switch.
G (group)	A combination command of P and M modes, which causes the programmer to expend flare payloads from all available sections in parallel in the quantity and time interval selected by the programmer.

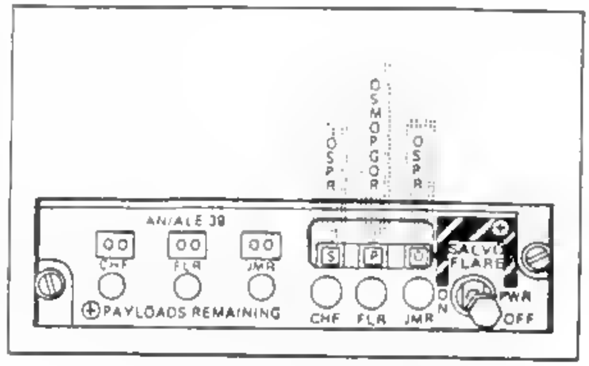


Figure 17-10. AN/ALE-39 Pilot's Control Panel (For Aircraft With AFC 82 Installed)

17.4.3.3 LOAD REMAIN Display Counter. Three LOAD REMAIN subtractive counters are provided to indicate the number of unfired CHF (chaff), FLR (flare), and JMR (jammer) cartridges remaining in the dispensers. Each counter has a reset knob to allow manual setting or resetting of each display to all integers between 00 and 99. The counters have mechanical stops at 00 and are not damaged by additional decrementing counter signals.

17.4.3.4 Programmer Control Panel. The programmer control panel (Figure 17-11) accepts command signals from the pilot control panel and provides the two sequencer switches with stepping pulses for dispensing countermeasures payloads from the dispensers.

Note

> Because of the location of the programmer (right wheel well), airborne reprogramming is impossible. Ensure the programmer selection is briefed, understood, and set prior to launch.

17.4.3.4.1 CHAFF B QTY Switch. The CHAFF B QTY switch has positions 1, 2, 3, 4, C, and R, which select the number of chaff bursts in one salvo. The C position permits continuous dispensing of individual bursts at the rate selected on the CHAFF B INTV switch. Dispensing continues until all chaff has been expended or until the dispenser control POWER/FLARE SALVO switch is positioned to OFF. The R position permits a random number of bursts in one salvo (four minimum or six maximum).

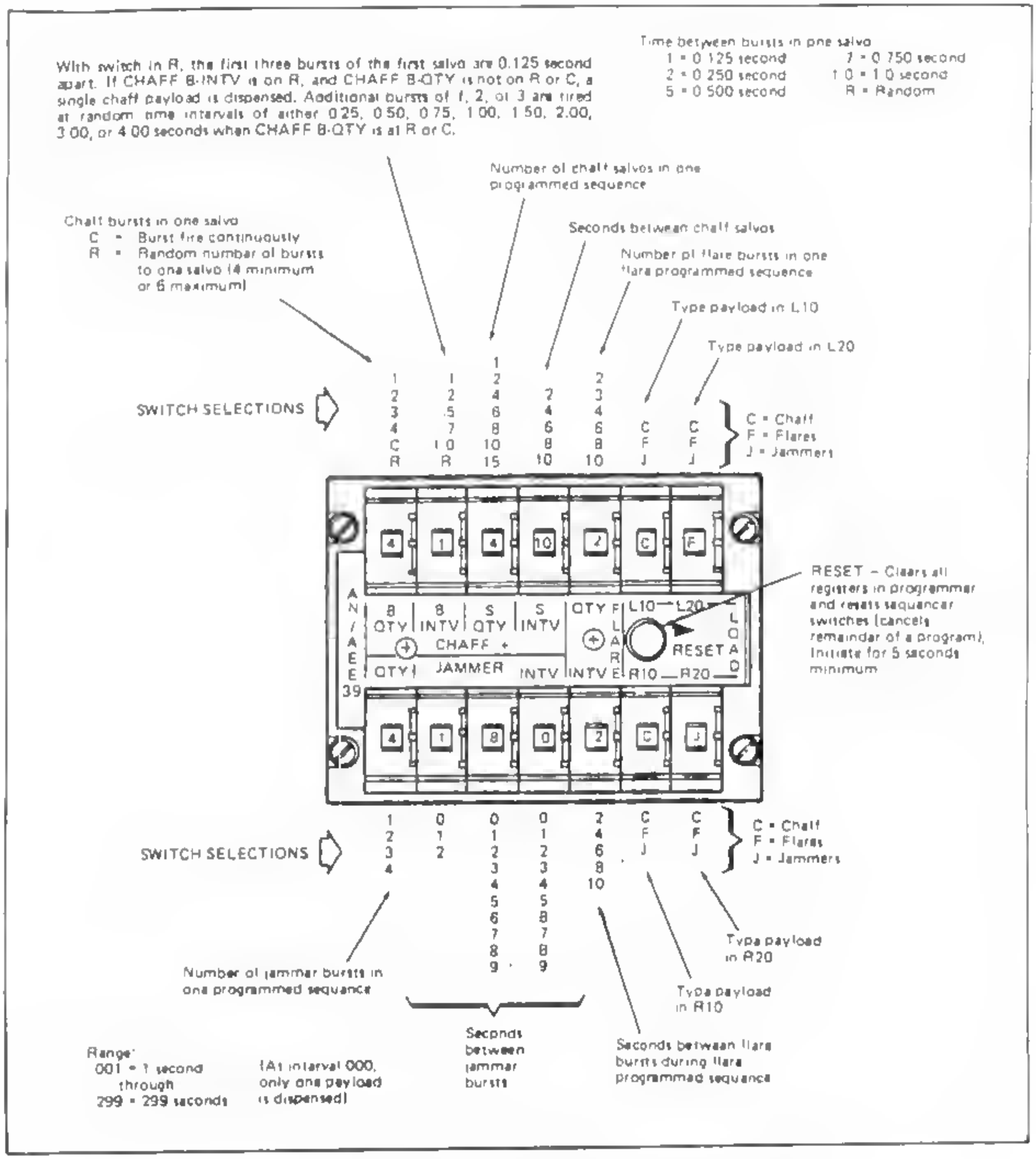


Figure 17-11. AN/ALE-39 Programmer Control Panel

17.4.3.4.2 CHAFF B INTV Switch. The CHAFF B INTV switch has positions 0.1 (0.125 second), 0.2 (0.25 second), 0.5 (0.5 second), 0.7 (0.75 second), 1.0 (1 second), and R (Random) which select the time interval

in seconds between each chaff burst in a salvo. With the CHAFF B INTV switch in R, the first three bursts of the salvo are 0.125 second apart. Additional bursts of 1, 2, or 3 are fired at random time intervals of either 0.25, 0.5, 0.75, 1, 1.5, 2, 3, or 4 seconds when CHAFF B QTY switch is at R or C. If CHAFF B INTV switch is on R and CHAFF B QTY is not on R or C, a single chaff payload is dispensed.

17.4.3.4.3 CHAFF S QTY Switch. The CHAFF S QTY switch has positions of 2, 4, 6, 8, 10, and 15, which select the number of chaff salvos in one programmed sequence.

17.4.3.4.4 CHAFF S INTV Switch. The CHAFF S INTV switch has positions of 2, 4, 6, 8, and 10, which select the time interval in seconds between ejection of each salvo in an automatic sequence.

17.4.3.4.5 JAMMER QTY Switch. The JAMMER QTY switch has positions of 1, 2, 3, and 4, which select the number of jammer bursts in one programmed sequence.

17.4.3.4.6 JAMMER INTV Switches. The three JAMMER INTV switches provide for selection of time interval between jammer bursts from 1 to 299 seconds.

17.4.3.4.7 FLARE QTY Switch. The FLARE QTY switch has positions 2, 3, 4, 6, 8, and 10, which select the number of flare bursts in one flare programmed sequence.

17.4.3.4.8 FLARE INTV Switch. The FLARE INTV switch has positions of 2, 4, 6, 8, and 10, which select the time interval in seconds between flare bursts during flare programmed sequence.

17.4.3.4.9 L10, L20, R10, R20 LOAD Switches. The four LOAD switches have positions of C (chaff), F (flares), and J (jammers), which are set by ground personnel to indicate which type of load is in each of the four dispenser sections.

17.4.3.4.10 RESET Switch. The RESET switch is used to clear all registers in the programmer and resets the sequencer switches (cancels remainder of a program). The switch must be activated for at least 5 seconds and must be activated every time you reset something.

17.4.3.4.11 INITIATE Switch Panel. An INITIATE switch (Figure 17-13) is located in both front and rear cockpits. The multiposition, momentary toggle switch has positions of CHF, FLR, and JMR, with center position off. Momentarily depressing the switch to CHF, FLR, or JMR will initiate a dispense function to the programmer as selected on the pilot's control panel.

17.4.4 Countermeasures Dispensing Set Operation. The countermeasures dispensing set is placed in operation by the POWER/FLARE SALVO switch to the ON position. This applies +28 vdc to the programmer and enables the search and fire circuitry. Additionally, the safety switch must be activated by removing the safety pin. Countermeasures materials may be dispensed manually or automatically (programmed). Manual (single) dispensing of chaff, flares, or jammers can be performed during a programmed dispensing sequence without disrupting the program. The number of bursts and the time lapse between bursts for programmed dispensing of chaff, flares, and jammers, and the number of chaff salvos and the time lapse between chaff salvos in a programmed sequence are selected on the programmer control panel. On the pilot's control panel, set the LOAD REMAIN display counters to indicate the number of each type payload material (chaff, flares, jammer) loaded in the dispensers. Flares may be salvoed at any time (in flight) by placing the POWER/FLARE SALVO switch to the FLARE SALVO position. All remaining flares, regardless of loaded location, are dispensed in a rapid-fire sequence.

17.4.4.1 Manual Operation (Single Dispensing). After the dispensing system is placed in operation by positioning the POWER/FLARE SALVO switch to ON, position the mode selector switches on the pilot's control panel to the indicated position.

1. CHF mode switch —"S" (single)

2. FLR mode switch —"S" (single) or "M" (multiple)

3. JMR mode switch —"S" (single).

With the mode switches in "S" position, momentarily depressing the INITIATE switch to either CHF, FLR, or JMR, will dispense one payload of selected countermeasures material. With the FLR mode switch in "M" position, depressing the INITIATE switch to FLR will dispense from one to four flares simultaneously as a single dispense, depending on how the

four sections of the dispensers are loaded. If three sections have flares loaded, three flares can be fired simultaneously, or if only one section has flares loaded, a single flare will be fired.

17.4.4.2 Automatic Operation (Programmed Dispensing). After the dispensing system is placed in operation by positioning POWER/FLARE SALVO switch to ON, position the mode selector switches on the pilot's control panel to the desired position.

17.4.4.2.1 Chaff Dispensing. Place CHF mode switch to "P" position. With the mode switch in "P" position, momentarily depressing the INITIATE switch to CHF will initiate a programmed sequence of dispensing chaff payloads from the dispensers. The number of salvos, number of bursts for each salvo, timing interval between bursts, and time interval between salvos are determined by the setting of the programmer switches (CHAFF B QTY, CHAFF B INTV, CHAFF S QTY, and CHAFF INTV). With the CHAFF B QTY switch in "C" (continuous), the individual bursts are dispensed continuously at the rate determined by the position of the CHAFF B INTV switch.

Note

Continuous dispensing can be terminated only by positioning the POWER/FLARE SALVO switch to OFF.

The positions of the CHAFF QTY and CHAFF INTV switches are meaningless when the CHAFF B QTY switch is in "C."

17.4.4.2.2 Jammer Dispensing. Place JMR mode switch to "P" position. With the mode switch in "P" position, momentarily depressing the INITIATE switch to JMR will initiate a programmed sequence of dispensing jammer payloads from the dispensers. The number of jammer bursts in one programmed sequence and the time interval between jammer bursts are determined by the setting of the programmer switches (JAMMER QTY and JAMMER INTV).

17.4.4.2.3 Flare Dispensing

1. Place FLR mode switch to "P" position. With the FLR mode switch in "P" position, momentarily depressing INITIATE switch to FLR will initiate a programmed sequence of dispensing flare payloads from the dispensers. The number of flare bursts in one programmed sequence and the time intervals between flare bursts are determined by the settings of the programmer switches (FLARE QTY and FLARE INTV).

2. Place FLR mode switch to "G" position. With the FLR mode switch in "G" position, momentarily depressing the INITIATE switch to FLR will initiate a programmed sequence of dispensing multiple flare payloads (up to four flare dispensed simultaneously) from the dispensers. The number of multiple flare bursts in one programmed sequence and the time intervals between flare bursts are determined by the settings of the programmer switches (FLR QTY and FLR INTV).

17.4.4.2.4 Countermeasures Dispensing

1. Manual Operation (Single dispensing)

(a) POWER/FLARE SALVO switch . . . . ON

(b) CHF mode switch . . . . S

(c) FLR mode switch . . . . S or M

(d) JMR mode switch . . . . S

(e) INITIATE switch (Pilot's or Observer's) . . . . . CHF, FLR, or JMR (As Required)

Note

With FLR mode switch in M position, a multiple dispense of one to four flares will be released simultaneously if flares are loaded in more than one dispenser section.

2. Automatic Operation (Programmed)

(a) POWER/FLARE SALVO switch . . . . ON

(b) CHF mode switch . . . . P

(c) FLR mode switch . . . . P or G

(d) JMR mode switch . . . . P

(c) INITIATE switch (Pilot's or Observer's) . . . CHF, FLR, or JMR (As Required)

Note

With FLR mode switch in (G) position, a programmed sequence of multiple flare payloads will be dispensed.

3 Flare Salvo

(a) POWER/FLARE SALVO switch . . . . FLARE/SALVO

17.5 AN/ALE-39 COUNTERMEASURES DISPENSING SET (AFC 96 or 97)

For aircraft with airframe change 96 or 97 installed, the functions of the AN/ALE-39 are the same; however, the configuration of the system is very different.

17.5.1 Countermeasures Dispensing Set Controls and Indicators. All controls and indicators for the AN/ALE-39 are on the programmer control panel (located in the right-hand wheel well), the CMS Countermeasures page, the SALVO FLARE ON/OFF switch, and two INITIATE switches located on the front and rear cockpit instrument panels (Figure 17-12).

17.5.1.1 Countermeasures Page. The CMS Countermeasures page, selected by pressing the CM key on either CMS CDU, displays power status (ON/OFF), mode selection (program, single, multiple, or group) and payload remaining indications for chaff, flare and jammer countermeasures stores. Initial countermeasures payload may be programmed into the CMS from the keypad and as each store is dispensed. Indicators are limited to a maximum of 60 for each type of countermeasure store. All modes will indicate OFF when the page is initially displayed prior to programming. LS key action will have no effect if the SALVO FLARE ON/OFF switch is OFF (Figure 17-13).

17.5.2 Countermeasures Dispensing Set Operation. For aircraft with AFC 96 or 97 installed, the AN/ALE-39 is placed in operation the same way as aircraft with AFC 82 installed.

Once power is ON, go to the CM page of the CMS CDU. Set the load remaining counters to indicate the number of each type payload material loaded in the dispensers. In addition, select and display the programmer modes selected on the programmer (Figure 17-13).

17.5.2.1 Manual Operation. After the dispensing system is placed in operation, select the CM key on the CMS CDU. On the CM page, select CHAFF (LS2), JAMMER (LS3), and FLARE (LS4) to SINGLE with rotary LS key action. When the modes are selected to SINGLE, momentarily depressing the INITIATE switch to either CHF, JMR, or FLR will dispense one payload of selected countermeasures material.

17.5.2.2 Automatic Operation (Programmed Dispensing). After the dispensing system is placed in operation, select the CM key on the CMS CDU. On the CM page, select CHAFF, JAMMER, and FLARE to PROGRAM. When the modes are selected to PROGRAM, momentarily depressing the INITIATE switch to either CHF, JMR, or FLR will initiate a programmed sequence of dispensing the selected payloads from the dispensers.

17.6 AN/ALQ-144 JAMMER

The AN/ALQ-144 (Figure 17-14) is an infrared jammer. It is mounted on top of the aircraft fuselage near the aft end and is an omnidirectional system which confuses the guidance mechanisms of selected infrared missiles. The set consists of two units, the cockpit control panel and the transmitter.

The cockpit control panel is located on the pilot's control panel and contains an INOP lamp mounted near the sight on the pilot glareshield and the ON-OFF switch.

The source plus the rest of the set uses a maximum of 1.5 KW from the aircraft 28-vdc source, which produces a current drain of about 54 amperes. This fact should be taken into consideration during any electrical emergency.

The transmitter consists of a heat source, high- and low-speed modulators, covert window, and housing assembly. The transmitter generates and modulates heat and passes it through the covert window as invisible IR energy. The heat source and other components are cooled by forced air, and the hot air then exhausts from openings in the top of the transmitter.

17.6.1 Operating Procedures

1. ON/OFF switch — ON

Operate the AN/ALQ-144 for a minimum of 15 minutes if no fault conditions exist. After flight or when ALQ-144 is no longer needed, turn ON/OFF switch OFF. The IRCM light will illuminate for approximately 60 seconds after power is removed from the system.

If a fault condition exists in the AN/ALQ-144, the IRCM light will illuminate approximately 60 seconds after power is applied and will automatically turn off the AN/ALQ-144. The IRCM light will remain illuminated for approximately 60 seconds when the fault condition is encountered.

If IRCM light illuminates:

1. ON/OFF switch — OFF
2. Wait until IRCM light extinguishes (approximately 60 seconds)
3. ON/OFF switch — ON.

If IRCM light does not illuminate, system will operate normally.

If IRCM light illuminates (internal failure of AN/ALQ-144); ON/OFF switch — OFF.

The IRCM INOP light indicates a system malfunction. The following conditions will light these lamps: modulator speeds are out of tolerance, the source output drops below a fixed reference, or overheating occurs because of a fault in blowing cool air over the transmitter components. All of these faults will also cause the transmitter to shut down.

17.6.2 Reset/Fixed/Sweep (RST/FXD/SWP) Switch. The RST/FXD/SWP switch, located behind the built-in-test (BIT) indicator access panel on the base of the transmitter, has three positions; RST, which allows the BIT indicators to be reset; FXD, which allows for fixed frequency modulation; and SWP, which allows for sweep frequency modulation.

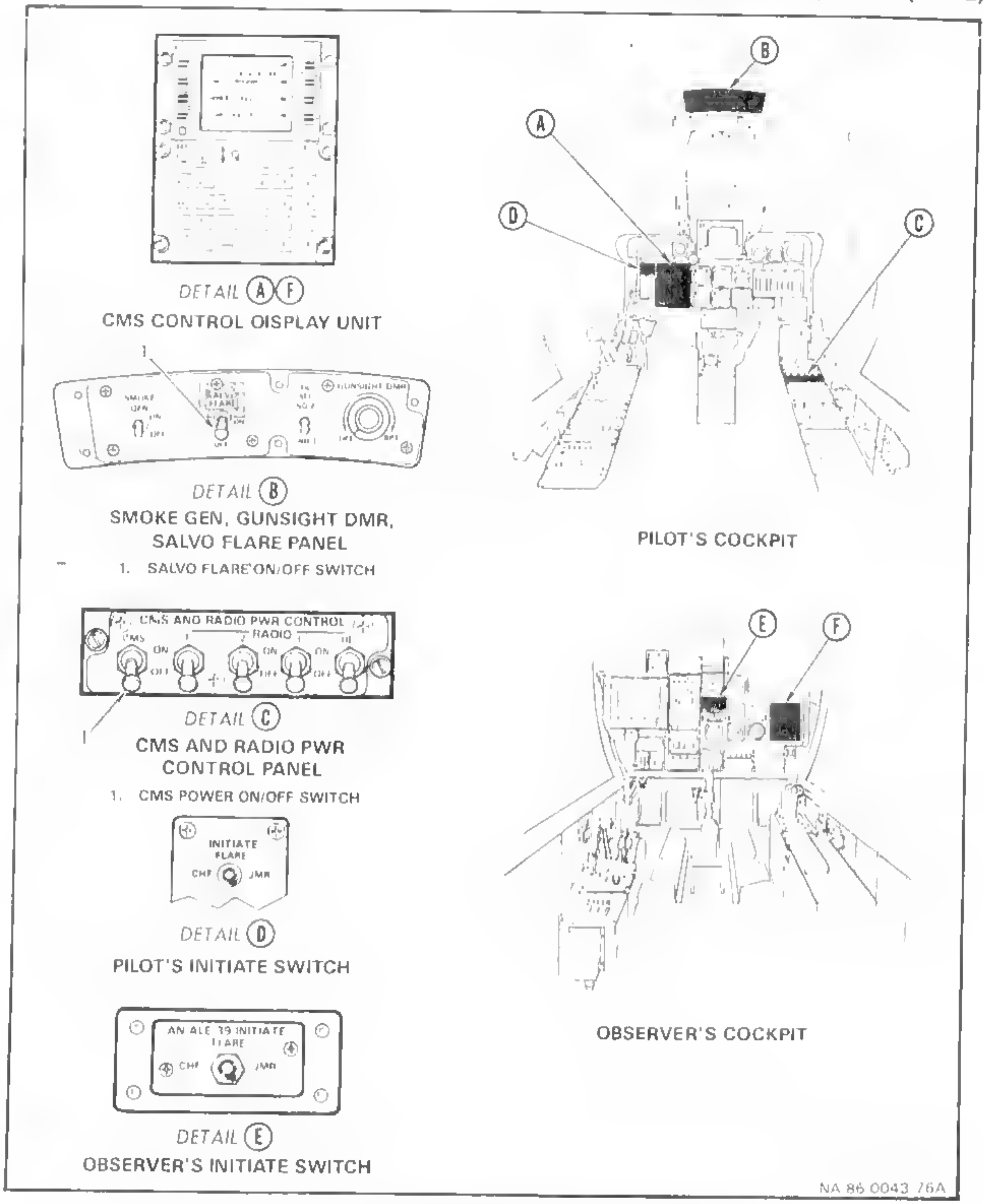


Figure 17-12. AN/ALE-39 Countermeasures Dispensing Set Control and Indicators (For Aircraft With AFC 96 or 97 Installed) (Sheet 1 of 2)

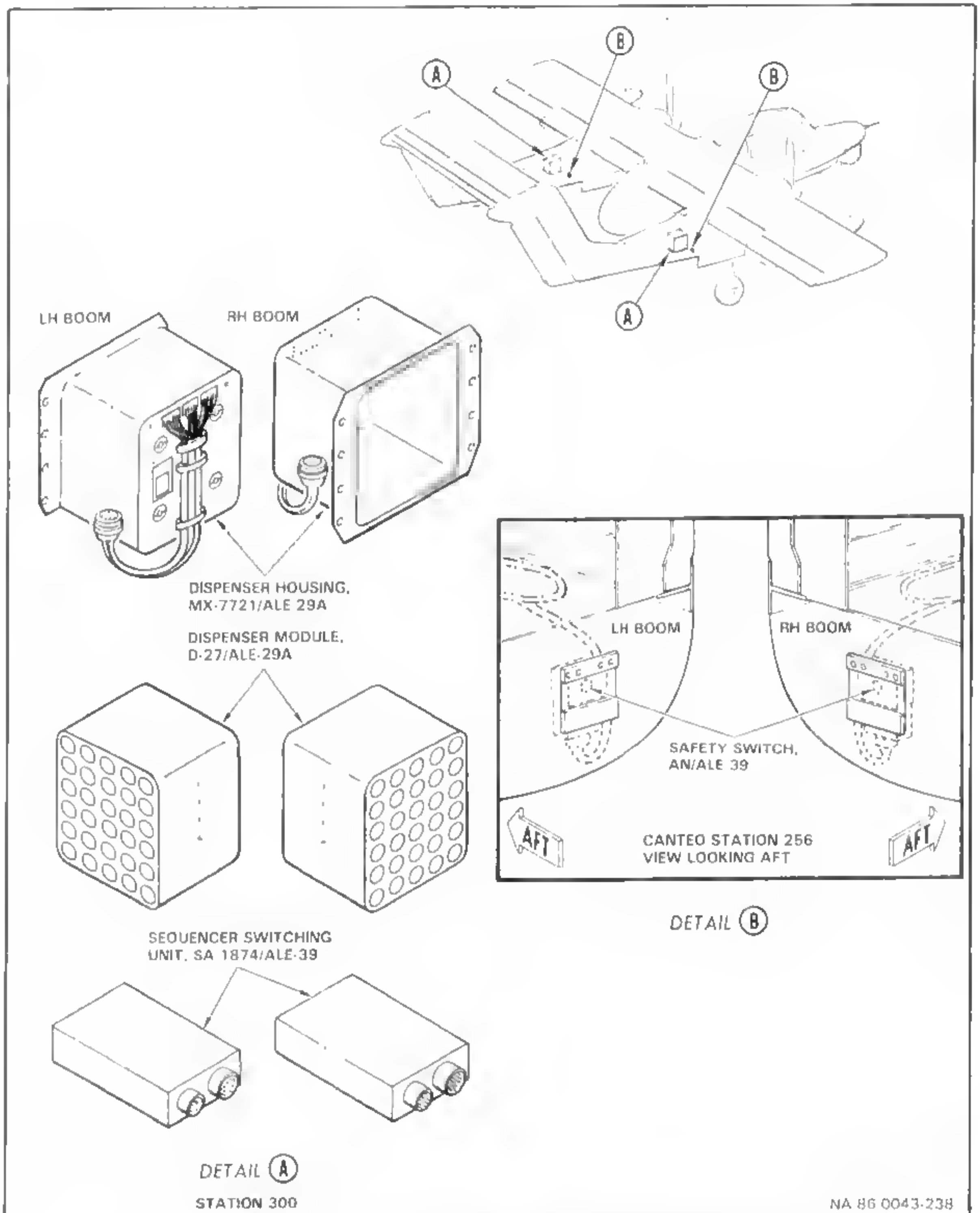
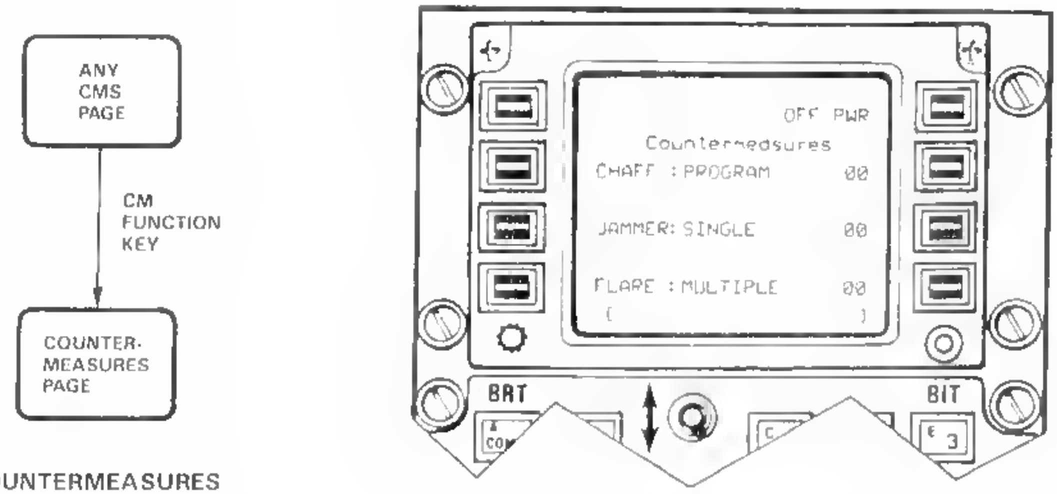


Figure 17-12. AN/ALE-39 Countermeasures Dispensing Set Control and Indicators (For Aircraft With AFC 96 or 97 Installed) (Sheet 2 of 2)



COUNTERMEASURES PAGE FLOW CHART

COUNTERMEASURES PAGE

- LS1 NO ACTION
- LS2 TOGGLE CHAFF MODE SELECT (OFF, SINGLE, PROGRAM, RWR)
- LS3: TOGGLE JAMMER MODE SELECT (OFF, SINGLE, PROGRAM RWR).
- LS4. TOGGLE FLARE MODE SELECT (OFF, SINGLE, MULTIPLE, OFF, PROGRAM, GROUP, OFF, RWR)
- LS5. NO ACTION DISPLAY CM POWER STATE
- LS6. ENTER PAYLOAD COUNT FROM SCRATCH PAD
- LS7 ENTER PAYLOAD COUNT FROM SCRATCH PAD
- LS8 ENTER PAYLOAD COUNT FROM SCRATCH PAD

NOTE

PAYLOAD COUNTERS WILL DECREASE WITH EVERY INITIATE SWITCH ACTIVATION HOWEVER, THE CMS DOES NOT HAVE THE CAPABILITY TO CROSS CHECK FOR MISFIRES OR DUD COUNTERMEASURE MATERIALS

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Figure 17-13. AN/ALE-39 CMS CDU CM Key Flow Chart and Page Display (For Aircraft With AFC 96 or 97 Installed)

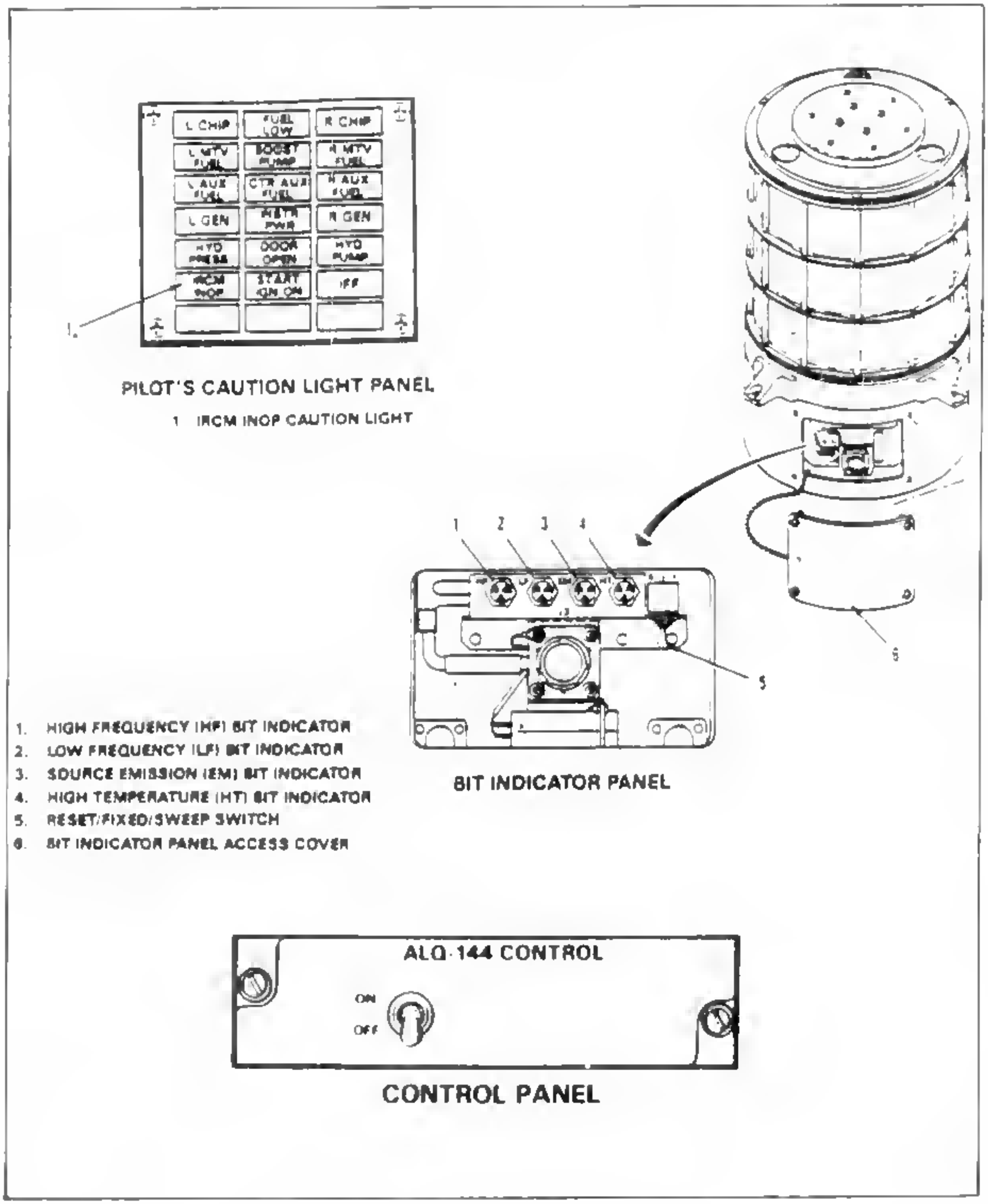


Figure 17-14. AN/ALQ-144 IR Jammer Components

PART V

Special Purpose Weapons and Equipment

CHAPTER 18

Night Vision Goggles

18.1. INTRODUCTION

In the mid-1960s, U.S. forces began looking for ways of overcoming the darkness on the modern battlefield, not so much to optimize it toward our advantage as to deny its use to the Vietnamese. We began with searchlights — simple and effective, but hardly designed for rapid maneuver and (worst of all) quite conspicuous. The need for enhanced night vision capability became evident as we pinpointed our position to the enemy we were trying to illuminate.

An intermediate answer came in the form of near-infrared searchlights and viewers. These were relatively simple and provided our forces with a means of viewing the battlefield without visible light. Unfortunately the simplicity of the viewers' image converter tubes soon made them commonplace, for both sides, and we once again found ourselves illuminating our own positions. What we really needed was a night sighting device that did not emit a traceable signature. We found that device in the image intensification tube.

18.1.1 Image Intensifiers. An image intensifier is an electronic device that amplifies available ambient light reflected from an object. The light enters into the image intensifier tube and is focused by the objective lens onto a photocathode receptive to both visible and near IR radiation (Figure 18-1). The photons of light striking the photocathode causes a release of electrons proportionate in number to the amount of light projected through the lens. In turn, the released electrons are accelerated away from the photocathode surface by an electrical field (produced by the device's battery source). The accelerated electrons are directed against a phosphor screen placed on a flat plate opposite and parallel to the photocathode surface. This screen emits an amount of light proportional to the number and velocity of electrons which strike it. A voltage is applied between the photocathode and the phosphor screen which accelerates the electrons, *brightening* the projected scene. Thus the picture delivered to the user has been converted from a small amount of light to accelerated electrons and back to light. The *amount* of light amplification produced in an image intensifier tube is referred to as the device's gain. The gain of a device is the ratio of the light taken in through the objective lens to the light delivered on the phosphor screen.

Generally we speak of image intensifier (or I_2) technology in terms of first-, second-, or third-generation systems. The next few sections will be dedicated to a generic description of those technologies.

18.1.1.1 First-Generation Image Intensifiers. First-generation technology, whose most familiar manifestation was seen in the starlight scope used by snipers in Vietnam, attained high light level gains by means of a three-stage configuration of the simple image intensification tube described above (Figure 18-2). The ensuing fiber-optic coupling provided for gains in the range of 40,000 to 60,000 (compared to gains of 40 to 60 attained in a simple stage tube).

The photocathodes utilized in I_2 tubes are processed, or *grown*, by vaporizing several elements in a vacuum chamber and depositing them on the vacuum side of the transparent input window before the vacuum seal is made. Photocathode growing is a very delicate process and the quality of the crystals grown in that process directly affects the luminous efficiency and sensitivity of the I_2 tube. First-generation tubes use an S-20 multialkali photocathode which provides for a sensitivity of between 400 to 850 nm (nanometers) with a broad peak from 500 to 600 nm. Since the sensitivity of the photocathode extends into the near infrared, they are able to detect sources in that region invisible to the unaided eye.

First-generation tubes are very durable and have a very long life, well into the ten thousand hour range. However, they possess significant deficiencies. First, they are extremely susceptible to *blooming*, a tendency for the tube to wash-out if a bright light source appears anywhere in the devices' field of view (FOV). As a result, in the first-generation tube, the overall contrast of the intensified image is greatly reduced. Secondly, first-generation tubes require relatively high voltages to attain the necessary energy levels for light amplification. The weakest parts of the first-generation system, in fact, are the 6.75 volt battery and the

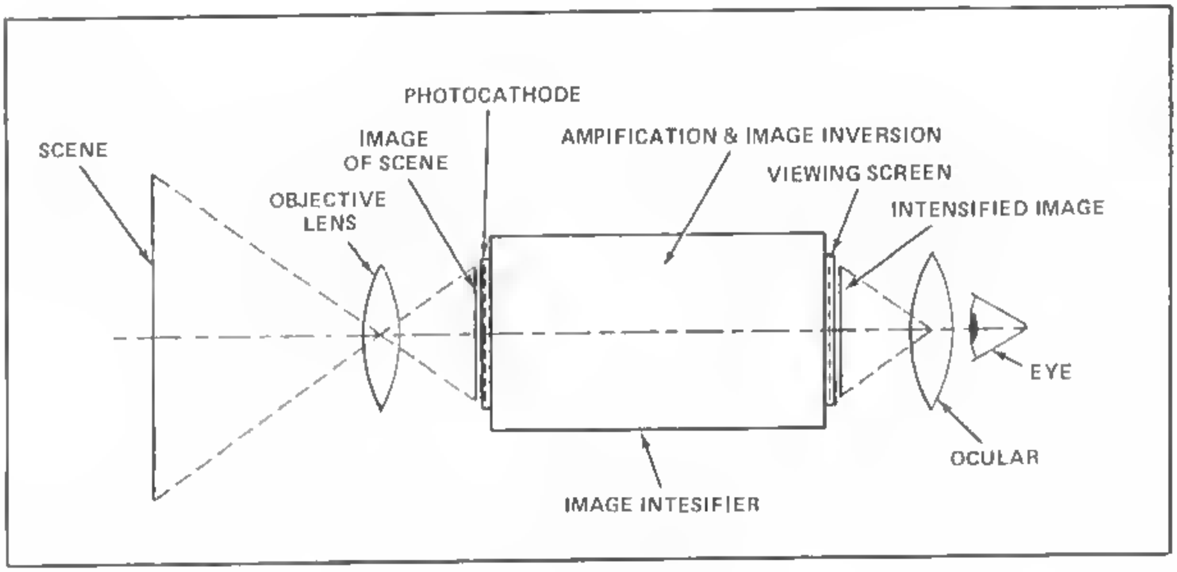


Figure 18-1. Image Intensifier

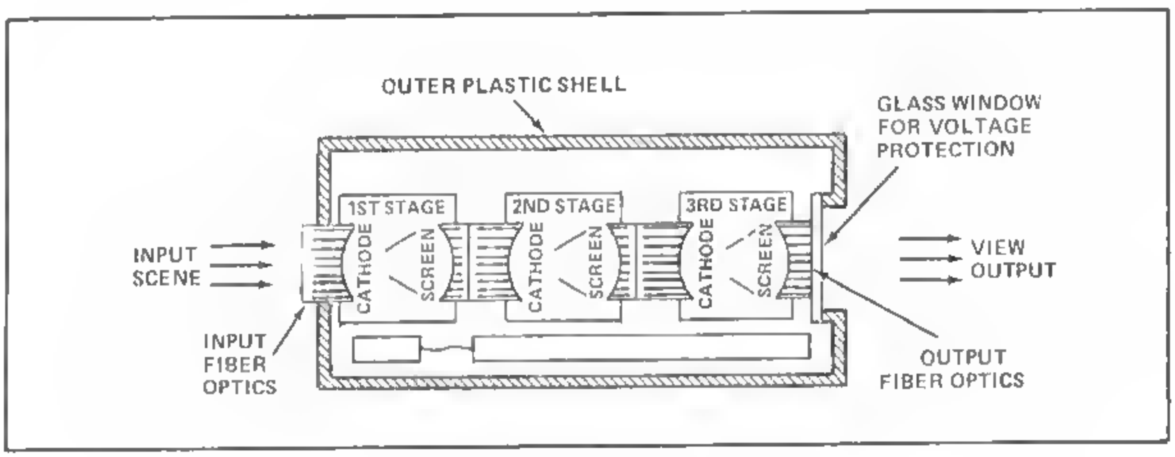


Figure 18-2. First-Generation Image Intensifier

oscillator module that converts the battery energy to an alternating current source for the intensifier's power supply. But the most significant drawback encountered with the first-generation device is its size. The starlight scope, for instance, is about a foot long. This is fine for snipers; not so good for aircrews.

18.1.1.2 Second-Generation Image Intensifiers. Much of the size invested in the first-generation tube was necessary because of the voltages required for sufficient electron velocity to produce the desired gains. But remember the amount of light produced by the I_2 tube is proportional to *both* the number and velocity of electrons that strike the phosphor screen.

Therefore, by increasing the number of electrons, we may decrease the required velocity of those electrons to achieve the same gains. Essentially, this is the concept upon which the second-generation I_2 tube was constructed, achieved by means of the microchannel plate (MCP).

The MCP (Figure 18-3) is a very thin (1 mm) wafer of tiny glass tubes (about 1-1/2 million). The inside passages of these tubes are coated with a material that causes secondary electron emissions. The wafer is situated in the second-generation tube next to the photocathode; hence, electrons accelerating from the photocathode are channeled first through the MCP. The tiny glass tubes are tilted in the MCP approximately 8° so that the electrons passing through are sure to strike walls. As they do, more electrons are emitted from the wall, each of which will in turn strike the wall again, emitting more electrons, etc. As a result of this channelization, for each electron that enters the MCP, as many as 10,000 will exit. These electrons are in turn accelerated forward, maintaining their relative spatial position, until they strike and excite the phosphor screen.

In the second-generation tube, the photocathode, MCP, and phosphor screen are in *proximity focus*; that is, located very close to each other, providing the miniaturization necessary for a helmet mounted system. This is made possible due to lower applied voltage requirements, 5,000 to 6,000 volts, as compared to first-generation tubes' applied potentials of up to 45,000 volts. Furthermore, by reducing the distances between these components, there is little or no image distortion caused by the influence of stray magnetic fields acting on the electrons. This image distortion occurs occasionally in first-generation devices.

In first-generation devices, sufficient spacing exits between the photocathode and phosphor screen to allow for image inversion to occur, as electrons actually crossover in the middle of the tube (Figure 18-4). This spacing, however, is not available in second-generation devices. Instead, image conversion is accomplished by attaching the phosphor screen to what is referred to as a fiber optic inverter. This inverter is actually a bundle of millions of microscopic light transmitting fibers. Left alone, the image presented on the phosphor screen could be observed on the other end of the bundle. For use in the tubes, however, the bundle is heated and given a 180° twist, providing the needed inversion to produce an upright image without requiring a second output lens.

Second-generation tubes are still somewhat susceptible to *blooming* when exposed to a bright light source, but this tendency is minimized with the introduction of the MCP. Whereas first-generation devices suffered saturation of the entire FOV when exposed, the MCP allows the saturation to be confined to individual channels; thus, contrast degradation is localized in the FOV. This localized saturation sometimes appears on the tube as a halo effect around the image of the bright light source. This halo effect will, however, also degrade the contrast of adjacent portions of the intensified images.

Localization aside, exposure to bright light sources left unchecked could result in damage to both the photocathode and the MCP. The power supply to the second-generation tube, therefore, has been designed with two automatic protection features. The first, an automatic brightness control (ABC) helps to protect the observer from bright flashes by automatically adjusting MCP voltage to hold output brightness to a preset level (restricting peak display luminance to between 0.3- and 0.9-foot-lamberts for a full range of input energy). The ABC does not control the number of electrons released from the photocathode; it controls the number of electrons that come out of the exit side of the MCP.

The second protection feature, the bright source protection (BSP) circuit, does, in fact, limit the number of electrons leaving the photocathode, by greatly reducing the voltage between the photocathode and the input side of the MCP. The feature automatically activates when input light levels cause excessive photocathode current to flow.

These two functions are extremely important in as much as the lifetime of a second-generation tube is largely a function of the lifetime of the photocathode. End of life for these is primarily caused by ion bombardment. The photocathode becomes contaminated by ions given off by the MCP as it is struck by electrons from the photocathode. This bombardment results in a gradual loss of luminous efficiency. The higher the light

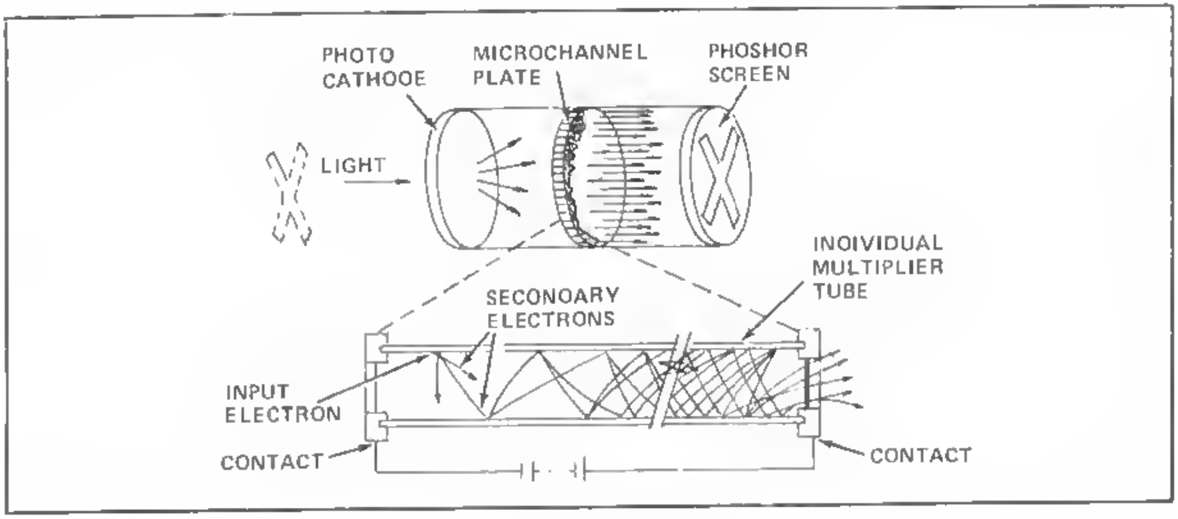


Figure 18-3. Microchannel Plate

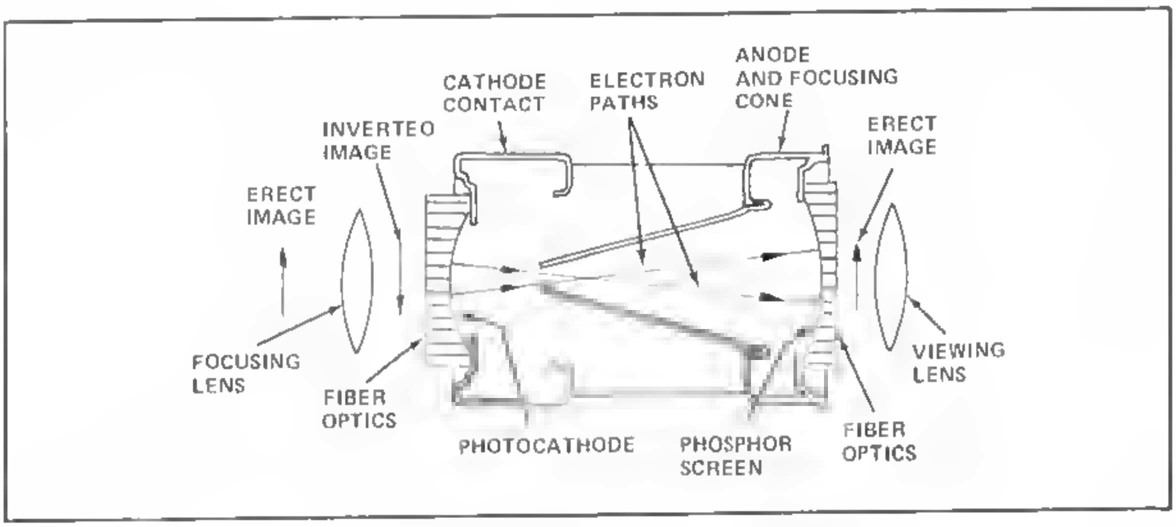


Figure 18-4. First-Generation Image Inversion

input, the more ions are generated, and the shorter the life expectancy of the tube.

Another factor that contributes to the reduced life of a second-generation tube is a gradual drop in secondary electron emissions through the MCP. Generally, operating at medium light levels, second-generation tubes can be operated for 2,000 to 4,000 hours, a marked reduction in durability as compared to first-generation tubes. Furthermore, the gain associated with second-generation tubes is somewhat lower than that of the first-generation system: 20,000 to 30,000, vice 40,000 to 60,000. And, it is important to point out that there are no inherent qualities in second-generation I_2 technology that would lead to improved resolution (this is also true of third-generation tubes).

Nevertheless, the improvements already cited in second-generation technology, particularly those associated with miniaturization and its accompanying adaptability for our use, clearly offset its comparable shortcomings.

18.1.1.3 Third-Generation Image Intensifiers. There are only two major changes that mark the difference between second- and third-generation image intensifiers; the S-20 multialkali photocathode has been replaced by a gallium arsenide photocathode, and a metal oxide film has been applied to the MCP. The results of these changes, however, are most noteworthy: significantly improved performance under starlight illumination levels, and a service life extended from 2,000 to 4,000 hours to first-generation levels of greater than 10,000.

The gallium arsenide photocathode surpasses the photosensitivity of the S-20 multialkali photocathode beyond 550 nm (Figure 18-5). The sensitivity of the new photocathode is more than 1,000 microamps and/or lumen, as compared to the 350 microamps and/or lumen average of the first- and second-generation photocathode. It is easy to become entangled in these numbers, but the end message is that the third near-infrared radiation from the stars is plentiful. Moreover, the 800 to 900 nm peak sensitivity range enjoyed by the third-generation intensifier has a five to seven times greater photon rate than in the visible region, which translates directly to increased gains. The addition of the metal oxide film to the MCP of the third-generation tube directly offsets shortened service life of the photocathode due to ion bombardment. The film is transparent to electrons; therefore, they pass from the photocathode to the MCP just as before. However, the film is not transparent to ions. Thus, they are *trapped* in the metal oxide film and prevented from contaminating the photocathode.

The only repercussion encountered with the introduction of the metal oxide film is an increase in bias voltage requirement between the photocathode and the

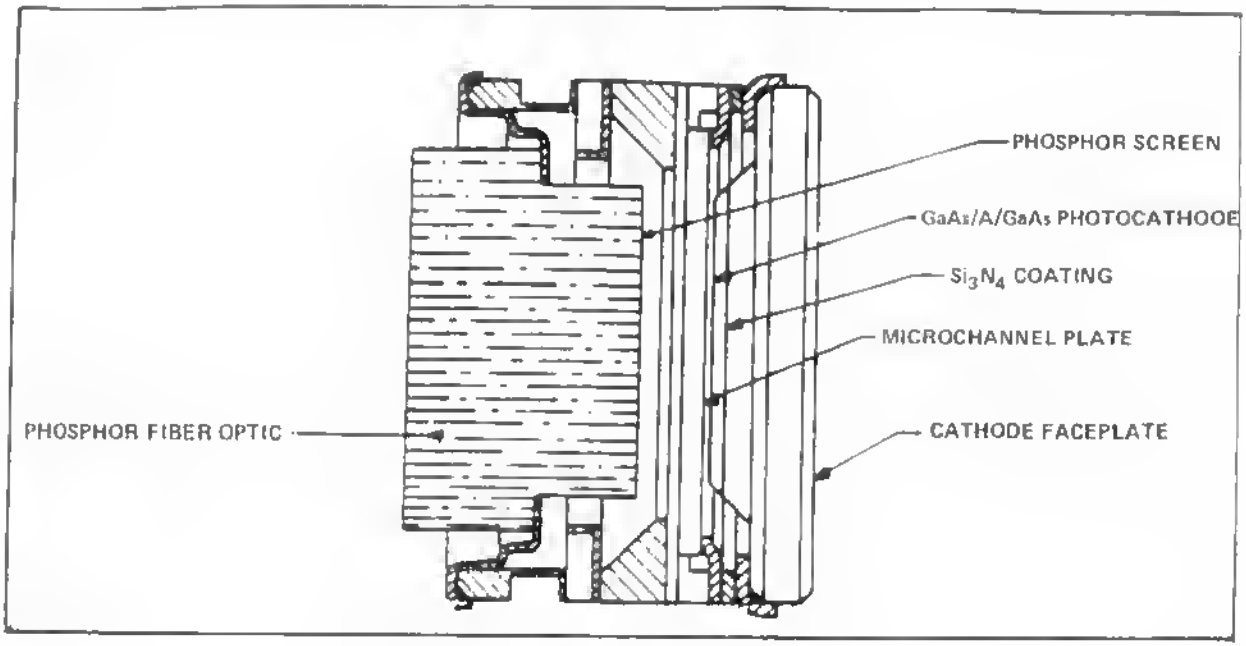


Figure 18-5. Third-Generation Image Intensifier

MCP. This, in turn, requires increased spacing between the two components to prevent arcing. Ultimately this spacing results in an increased halo size when viewing bright light sources (as compared to second-generation performance).

18.2 AN/PVS-5A NVG

The PVS-5 is a helmet mounted, second-generation image intensification system that was originally designed for ground force usage. The standard PVS-5 system consists of two identical monocular assemblies (tubes) mounted in an adjustable frame. The frame is contained in a *full-face* casing which (with foam padding provided) allows for the goggles to be mounted directly on the user's face. Each tube on the PVS-5 consists of an objective lens, a second-generation image intensifier, and an eyepiece. The system weighs approximately 28 ounces and is approximately 6.5 inches square.

The PVS-5 provides a 40° field of view (FOV), as opposed to an *unaided* (i.e., without NVG) peripheral view of 140°. The binocular visual acuity (BVA) of the PVS-5, derived under artificial clinical conditions, is 20/50. This is a degradation from the normal photopic level of 20/20 most aviators enjoy in daylight conditions. However, it is a very marked improvement over the unaided eye's capacity at night (scotopic vision) which, at best, is on the order of 20/400 to 20/200. What NVG is effectively doing then, is intensifying the ambient light about 1,000 times.

Some users are initially surprised to discover that the binocular goggles do not magnify their FOV in the manner of conventional binoculars. In fact magnification of the PVS-5 is 1:1. PVS-5s have a focal range of from 254 mm (10 inches) to infinity; this allows for adjusting the goggles for outside viewing as well as inside the cockpit.

The PVS-5 system can be effectively operated in temperatures ranging from -53.8 °C to 51.7 °C.

18.2.1 PVS-5 Modified Face Plate (MFP). Some of the most commonly voiced complaints surrounding PVS-5s were: lack of any peripheral vision; inability to read normal maps; eyepieces that fogged easily; inability to wear corrective lenses; a need to manually focus to view inside the aircraft and then refocus outside; and (the most often heard complaint) night vision goggles are uncomfortable to wear and cause fatigue. As an interim measure (while waiting for the ANVIS system), the modified faceplate PVS-5 (Figure 18-6) serves to offset many of the difficulties encountered with the *full force* system.

The most obvious advantage of the MFP is peripheral view afforded by the removal of the bottom section of the PVS-5. This provided an additional 30° of vertical scan and 20° of lateral unaided vision to each side. The additional vertical parameter allowed pilots to *look under* the goggles for normal map reading and cockpit monitoring, while at the same time retaining the ability to look through the goggles for outside viewing. Shortcomings involving the image intensification tubes themselves (FOV, visual acuity, stereopsis) remained unchanged with the faceplate modification.

The problem of eye lense fogging on the standard PVS-5s was because of the pilot's breath being enclosed in the faceplate. The MFP has completely eliminated this problem. Likewise the cutaway section of the MFP allows the user to wear eyeglasses with the goggles.

The discomfort often cited with wearing the standard PVS-5 was partially alleviated with the MFP. The MFP weighs only four ounces less than full face goggles, but the design removes pressure that was exerted on the cheek bones by the face cushion.

Some drawbacks associated with the MFP involved difficulties in the mounting, removal, goggle alignment and adjustment, and helmet rotation. Most of these maladies were diminished or eliminated with the introduction of the counterbalance mounting system.

18.3 AN-AVS-6, AVIATOR NIGHT VISION IMAGING SYSTEM (ANVIS)

As indicated by its name, ANVIS was a system designed from the outset for aviators. ANVIS is a lightweight, self-contained, helmet mounted third-generation image intensification system (Figure 18-7). The binocular consists of two identical monocular assemblies mounted on a pivot adjustment shelf (PAS). A helmet mount assembly is provided to attach the binocular to the crewmember's helmet.

The ANVIS system is powered by a power pack consisting of a housing and a three-position switch (Figure 18-8). It contains two batteries. One is required; one is redundant. There are two versions of ANVIS in the Marine Corps. ANVIS (V)1 (Figure 18-7) is designed for compatibility with the SPH-3 helmet. ANVIS (V)2 (Figure 18-9) features an offset mount on the pivot adjustment shelf for compatibility with the HGU-54/P Helmet Sight Subsystem (HSS) helmet. The binoculars on both systems are identical.

Several of the operational characteristics of ANVIS are the same as those of the PVS-5 system. The FOV

Figure 18-6. PVS-5 Modified Faceplate (MFP)

afforded through ANVIS is 40°, the same as with the PVS-5. Likewise the magnification is 1:1, and the focal range is 10 inches to infinity. The ambient temperature limits of operation are -56 °C to 52 °C; very similar to the -53.8 °C to 51.7 °C for PVS-5.

Visual acuity of ANVIS at first glance is also quite similar to the PVS-5. Under artificial clinical conditions ANVIS produced 20/40. However, under ambient illumination conditions encountered at starlight levels, vision was reduced to 20/80 on ANVIS, and 20/100 on PVS-5.

There are several more obvious comparisons that can be made between the PVS-5 and ANVIS that point to advantages in the latter system:

1. A *cleaner* peripheral view that allows for greater access to cockpit and/or instrument information.

2. A fail safe battery system with a warning light (3.0-volt battery only).

3. A significantly lighter weight (16 ounces) with a ready made counterbalance in the power pack.

4. An integrated mounting system that features a flip-up and/or flip down storage capability. Moreover, the ANVIS possesses a breakaway feature designed to separate the binocular from the helmet mount under a 10g crash load.

However, it is the aforementioned difference in visual acuity that points to the greatest advantages of ANVIS over the PVS-5; advantages borne out in contrast sensitivity, improved operational efficiency, and greater system resolution.

18.4 NVG POWER SOURCES

There are presently only two types of batteries that may be used in the Marine Corps ANVIS and PVS-5 NVG; the 2.7-volt mercury battery (designated BA-1567/U) and the 3.0-volt lithium battery (designated BA-5567/U). The service life of both types of battery will be affected by the temperature of their environments. The batteries can be used interchangeably in either the PVS-5 or the ANVIS system, but a significant service life advantage is enjoyed with the lithium battery. The following tables will illustrate this point

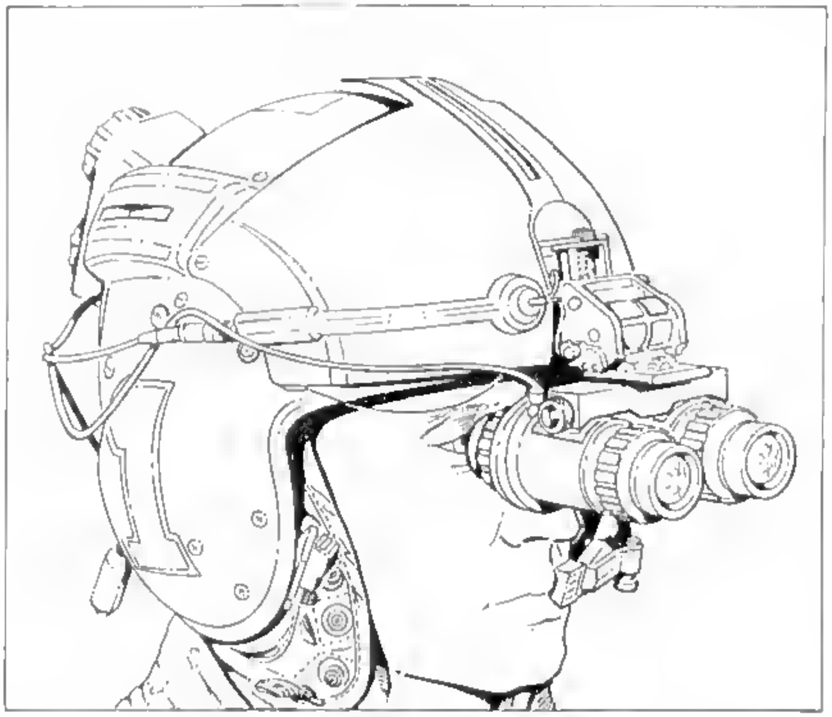


Figure 18-7. AN/AVS-6, ANVIS

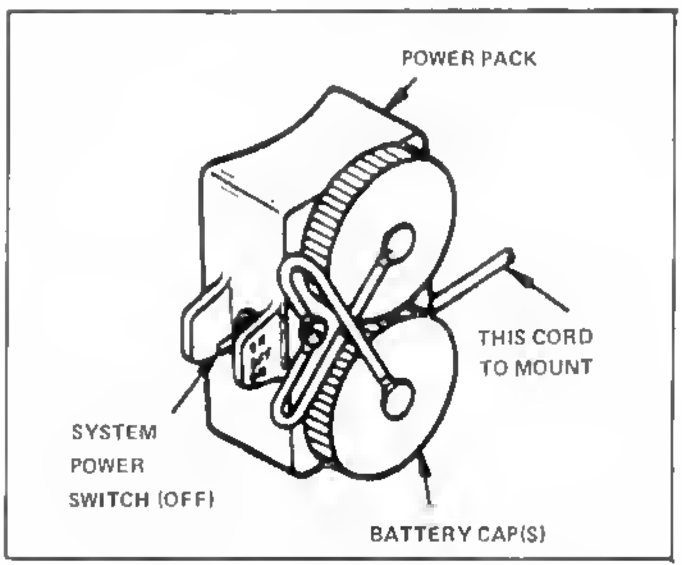


Figure 18-8. ANVIS Power Pack

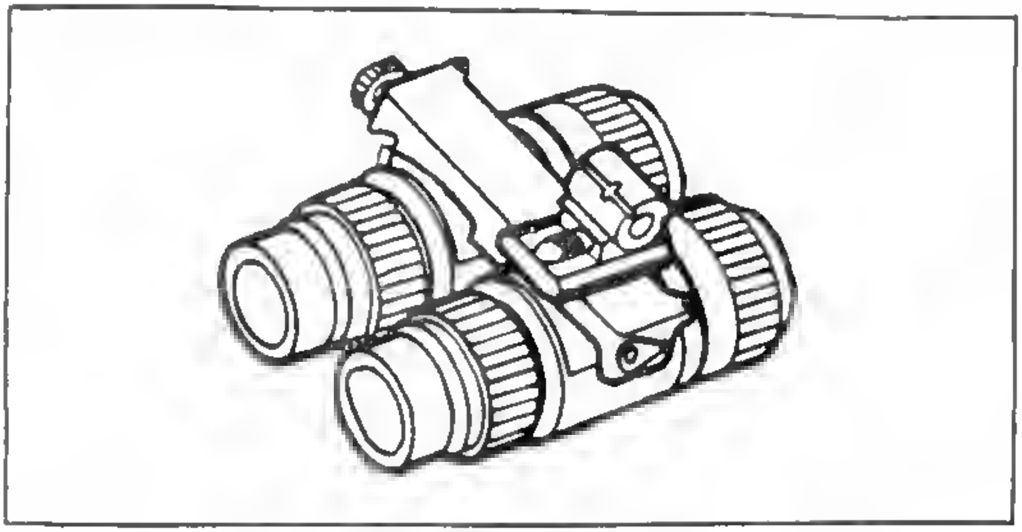


Figure 18-9. ANVIS (v) 2

Hours of Service AN/PVS-5A

Temp (F)	Mercury	Lithium
100	24.0	32
70	24.0	32
0	3.2	24
-20	0.0	18

Hours of Service ANVIS

Temp (F)	Mercury	Lithium
100	6/12	13/16
70	6/12	13/16
0	0.0/1.6	9/12
-20	0.0/0.0	5/8

A new battery pack for the ANVIS system was scheduled to be phased into production for the Marine Corps and the U.S. Army in 1988. This pack would be capable of utilizing both the mercury and lithium battery, as well as an "AA" alkaline battery. Given the temperatures listed in chart above, the projected battery lives for these in the ANVIS system (min and/or max) are 10/22 hours, 10/22 hours, 5/10 hours, and 1/3 hours, respectively.

In addition to the obvious service life advantage of the lithium battery over the mercury, several other benefits recommend it. With the ANVIS system, the lithium battery provides a 20- to 30-minute warning flash through an LED before power expiration. A similar type of warning has reportedly been attained with the mercury battery, but its occurrence has been far less documented and, in fact, cannot be predicted.

Another feature of the lithium battery is the built in safety vent around the battery's casing. This vent allows the battery to release gas pressure in the event that a malfunction forces that pressure too high. Venting may be sensed through smell, the sound of gas escaping, or through irritation of the eyes. When safety vents have operated, batteries must still be handled with care when removing them from the power pack.

WARNING

Do not heat, puncture, disassemble, short circuit, attempt to recharge, or otherwise tamper with lithium battery BA-5567/U. Turn off the NVG if the battery compartment becomes hot. Wait until batteries have cooled before removing them.

18.5 PERFORMANCE COMPARISONS OF PVS-5 AND ANVIS

An important feature that sets ANVIS apart from the PVS-5 system is its low light level performance (i.e., sensitivity). As illustrated in Figure 18-10, the ANVIS image intensification system outperforms the

PVS-5 because of improved sensitivity in the red and near infrared region of the spectrum.

A recent comparison study proved the advantage of the ANVIS over the PVS-5 under varying level of illumination. Testing was conducted for realistic scenarios in typical operating environments. Scenarios included terrain flight, confined area landing, and formation flight. Additional testing was conducted on marked ranges so as to permit accurate measurement of distances during obstacle and/or target acquisition and identification. Among the findings of the study were the following:

1. Acquisition and/or identification ranges varied with illumination, altitude, airspeed, and type NVG.

2. Acquisition and/or identification ranges were greater with ANVIS than with PVS-5 under all test conditions.

3. Pilots with ANVIS were able to acquire targets an average of 3 to 5 seconds prior to those with PVS-5 NVG under most conditions.

4. Pilots were able to acquire targets under overcast starlight conditions in a sparsely vegetated desert with ANVIS. However, identification ranges were reduced to the immediate proximity of the target. Pilots were unable to acquire or identify targets at the same altitudes and ranges on PVS-5.

5. Pilots were able to acquire and identify targets under overcast starlight conditions in a heavily vegetated environment with ANVIS. Pilots were unable to acquire or identify targets at the same altitudes and ranges on PVS-5.

These results led to conclude that *ANVIS outperformed PVS-5 NVG under all circumstances during the evaluation.* This was hardly surprising in that the gain (ratio of light into an image intensifier to light out) from ANVIS is 25,000, compared to a gain of 10,000 for the PVS-5.

It is this gain and accompanying sensitivity that provides an example of a condition in which PVS-5s provided greater contrast than ANVIS. In a comparative visual performance study between ANVIS and PVS-5,

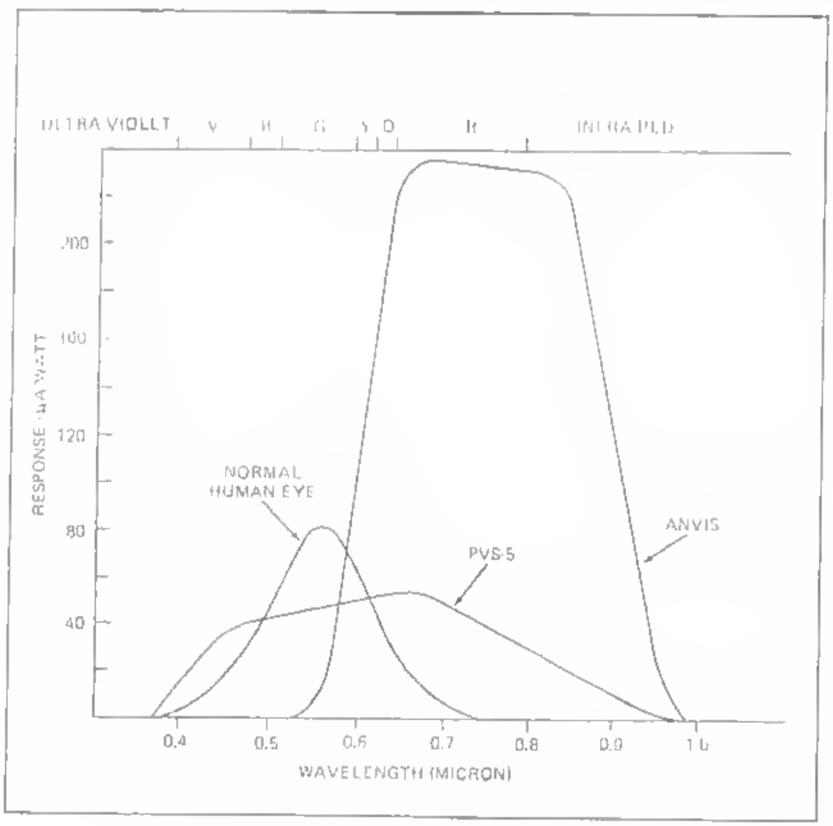


Figure 18-10. Comparison of Sensitivities

the Air Force discovered that in a desert environment (under high ambient light conditions) PVS-5s allowed acquisition of a road under observation when the ANVIS could not. The reason for the apparent phenomenon was that the ANVIS image intensifiers were equally sensitive to the road and its immediate surrounding foliage. Thus, there was no contrast gradient between the road and its surroundings to allow visual discrimination. This (the study surmised) was obviously due to the enhanced response of ANVIS in the IR end of the spectrum. The PVS-5, on the other hand, could discriminate the roadway from surrounding terrain because its intensifiers were not as sensitive to the weak IR light that the road reflected. Hence, the spectral radiation reflected from the road surface did not elicit a response from the PVS-5s, so it was seen as essentially dark. The surrounding terrain and foliage, however, were brightly visible to the PVS-5 tube. In effect, the roadway was detected by the PVS-5 because the system was not sensitive to the road, but was sensitive to the surroundings. Conversely the ANVIS did not allow detection of the roadway because it was equally sensitive to the road and its surroundings. No contrast difference could be discriminated.

18.6 NIGHT VISION GOGGLE OPERATIONS

As with any system, the key to maintaining the operational efficiency of the PVS-5 and ANVIS NVG is proper preflight and postflight care. Likewise, ensuring that the NVG is properly mounted and adjusted prior to each flight is essential to successful NVG operations. Improper adjustment of goggles can result not only in less than optimum operation of the systems, but converging or diverging vision and neuromuscular (accommodative) eye fatigue.

18.6.1 ANVIS/PVS-5 Preflight Care. The following are preflight care considerations directed for both ANVIS and PVS-5.

1. Check the objective and focal lenses for smudges, scratches, and dust. Clean lenses with lens paper. Use of tissues, clean cloths, etc., is not recommended as a matter of course because of the possibility of introducing abrasives to the goggle lens. Government issued lens paper (FSN 1.640-00-597-6745) can be acquired through the supply system.

2. If necessary to remove grease or dirt, the lens paper may be dampened.

3. (PVS-5 only) Inspect the plastic housing for cracks. Particular attention should be paid to the side snaps on the MFP which connect to the surgical tubing snaps in the approved helmet mounting system. The plastic area surrounding these has been weakened by the cutaway process. Cracks developed here that go undetected in preflight could expand and break in flight.

4. Check the monocular housings for cracks and general security.

5. Check wiring and contacts for breaks, corrosion, and general security.

6. Ensure that all adjustment knobs and levers are free of dust, dirt, and grime.

7. Remove all accessories from the NVG carrying case. Turn the case over and shake out any sand or dirt. Wipe the interior and exterior with a clean, dry, lint free cloth. If necessary, dampen the cloth to remove grease and dirt. Inspect the protective caps for the objective and focal lenses for cleanliness prior to returning them to the lenses.

18.6.2 ANVIS Test Set (TS-3895/UV). Prior to flight, both PVS-5 and ANVIS tubes should be checked to verify their operational efficiency on the TS-3895/UV test set.

18.6.3 NVG Preoperational Checks and Adjustments. In a binocular helmet-mounted system, such as the NVG, there are two images, one for each eye. The two images may differ in several ways, and both horizontal and vertical alignment error may result in image differences. Alignment errors may result because of a lack of parallelism of the two optical axes (that is, parallelism between each eye and each image viewed). To completely remove this error in the PVS-5 and the ANVIS systems is presently an unattainable goal because of prohibitive costs and an unacceptable penalty in added weight and size. Some imperfection can be present without appreciable adverse effects. Figure 18-4 depicts different types of alignment errors and optical image differences that the NVG user may encounter.

With a properly adjusted binocular device and individual fuses the two images fuze into one so rapidly that the user may never perceive two images being viewed. This fusion involves both neural and eye muscle effort. The effort is both unconscious and rapid. When alignment errors and image differences worsen, fusion is still rapid, but eyestrain may ensue. Where misalignment is more pronounced, fusion becomes more difficult and eventually is not possible (i.e., two separate images are seen). Seeing a double image of a single object is called diplopia and results in extreme eyestrain.

Efforts to maintain fusion (even subconscious ones) may have a negative cumulative effect. NVG that

seem to be entirely adequate (i.e., having no noticeable adverse effects) when used for a short period of time may prove to be intolerable when used for longer periods. Sustained conditions may result in eyestrain and visual fatigue, and headaches may occur. A headache, even a severe one, may develop when no eyestrain or visual fatigue is apparent. In this instance, the user is not likely to attribute the headache to optical binocular misalignment. Headaches will generally develop directly behind the ears and continue down the back of the neck.

In addition, there is a wide range of individual user differences in misalignment tolerances. Some individuals can tolerate with no obvious adverse effects greater misalignment than can others. On the other hand, alignment error unnoticed or undetectable by one individual may be totally unacceptable to another.

Image misalignment caused by faults or errors identified in Figure 18-11, which are severe enough to deny binocular fusion into one perceived *picture*, causes either double vision (diplopia) or suppression of vision in one eye. If suppression occurs, the observer will be unaware of it and will perceive only one image. However, visual capability is degraded when both images are fused. Interpupillary distance (IPD) and binocular adjustments are essential if the NVG are to be utilized to their fullest potential.

18.6.3.1 Preoperational Checks Required Before Donning NVG. Refer to Figure 18-12 as required for adjustments.

18.6.3.1.1 Vertical Alignment. Check to ensure that each tube is not tilted up or down in relation to the other tube.

18.6.3.2 Preoperational Checks Required After Donning the NVG. The following checks will take place with the NVG attached to the helmet, the helmet placed on the user's head, and NVG turned on.

CAUTION

To prevent damage to the image intensifier tubes, operational checks on the PVS-5 and ANVIS must be accomplished in nighttime (darkened) conditions only (with the lens cap off). Turning on the goggles in daylight or other bright light conditions (with or without lens caps on) can result in damage to the tubes.

18.6.3.2.1 Interpupillary Distance (IPD) Adjustments. If NVG eyepieces are not precisely aligned with the pupils of the eyes, less than optimum visual acuity and FOV will be obtained with the NVG. Proper alignment of the eyepieces is achieved when the distance between the tubes exactly matches the distance between the user's pupils. When the IPD of the goggles is properly adjusted, the edges of the images in both tubes will be clear and there will be a slight overlap of the tubes themselves (Condition A, Figure 18-13). Improperly centering the tubes over the pupil will result in either divergent or convergent vision and a degradation in visual acuity.

FAULT OR ERROR	DEFINITION
VERTICAL MISALIGNMENT	ONE OPTICAL AXIS IS TILTED UP OR DOWN WITH RESPECT TO THE OTHER AXIS. DIFFERENCE IN VERTICAL POSITION OF IMAGES.
HORIZONTAL MISALIGNMENT	ONE OPTICAL AXIS POINTS INWARD OR OUTWARD.
ROTATION DIFFERENCE	ONE IMAGE IS ROTATED (TILTED SIDEWAYS OR TWISTED).
LUMINOUS DIFFERENCE	ONE IMAGE IS LESS LUMINOUS (DIMMER) THAN THE OTHER.
CONTRAST DIFFERENCE	THE TWO IMAGES DIFFER IN CONTRAST.

Figure 18-11. Alignment Errors and Optical Image Differences

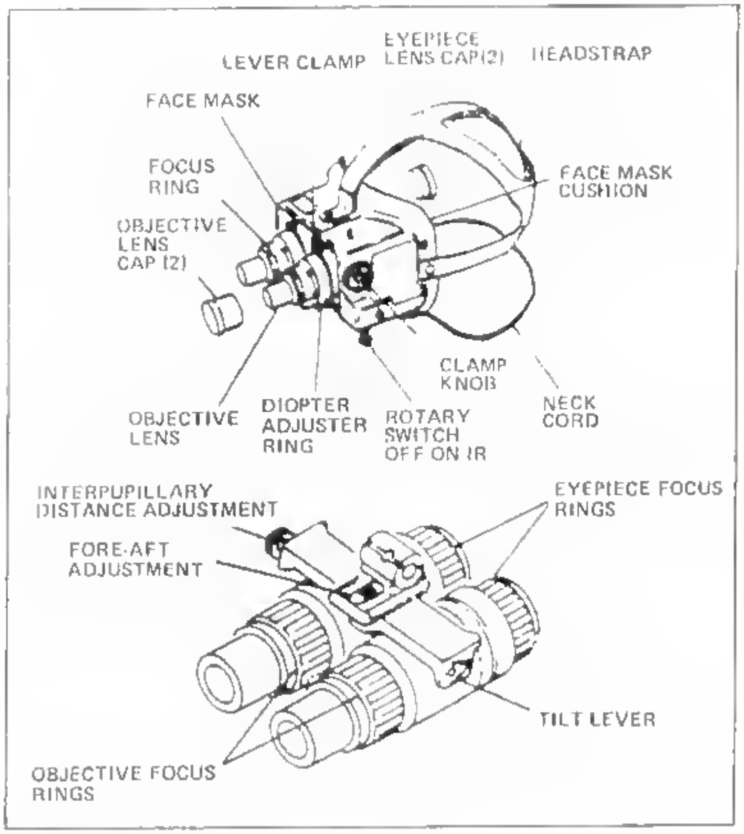


Figure 18-12. AN/PVS-5 and ANVIS Nomenclature

1. Focus on an object at *optical infinity*, or slightly beyond (approximately 28 feet to infinity, with the optimum being less than 50 feet to ensure the focusing object's resolution provides adequate detail).

2. Adjust the right and left focus knobs for infinity by turning them fully counterclockwise (PVS-5 and ANVIS).

3. Loosen the clamp knob on both sides of the NVG (PVS-5) and adjust the tubes to a comfortable distance from the eyes that will provide sufficient eye relief. For individuals that wear spectacles this may be farther away. For ANVIS, use the fore and/or aft adjustment knob. Keep in mind that positioning the tubes to the farthest outward limit may slightly reduce FOV.

4. For PVS-5, lightly tighten the clamp knobs and loosen the interpupillary lever clamp.

5. Focus (as described in step (a) above) one eye, with the other monocular covered, by adjusting the diopter adjustment ring (DAR) on the monocular (PVS-5), or the eyepiece focus ring (ANVIS), for clarity.

6. Move the tubes manually (PVS-5), or with the eye span adjustment (ANVIS), close together or farther apart until clarity is attained around edges of the circle (Condition B, Figure 18-13).

7. If only the outside edges are blurred, the tubes are too close together (Condition C, Figure 18-13).

8. If only the inside edges are blurred, the tubes are too far apart (Condition D, Figure 18-13).

9. If the upper or bottom edges of the image are blurred, the tubes are tilted or not properly centered over the pupil (Condition E, Figure 18-13). Correct this condition by adjusting the tubes with the clamp knobs (PVS-5), or tilt adjustment lever and vertical adjustment knob (ANVIS).

10. If the entire periphery of one or both tubes is blurred, the DAR (PVS-5) or eyepiece lens (ANVIS) is not properly adjusted or the monoculars

are too far from the eyes (Condition F, Figure 18-13).

11. Repeat the IPD adjustment process for the opposite eye. The entire process for adjusting IPD may seem lengthy, but after one or two times running through the process it will become second nature. Moreover, the scales on the vertical shelf and the DAR of the ANVIS will allow the user to begin this process at *personal measurements.*

12. When step (11) above has been completed, tighten the interpupillary lever clamp (on PVS-5) to secure tube separation. For ANVIS, no additional action is required to secure tube separation. When the tube edges are clear, the resultant binocular view through the NVG tubes should appear as two circles, slightly displaced laterally (Condition A, Figure 18-13). The slight lateral displacement of the tubes is indicative that each tube is nearly centered on the pupil of each eye and that the best visual acuity possible has been attained. If this condition is not achieved, repeat the IPD process. If still not achieved, the tubes are probably severely misaligned and, if utilized, may result in eyestrain, optical fatigue, headaches, reduced FOV, and some degree of reduction in visual acuity because of convergent or divergent vision. The degree of the maladies associated with this misalignment will be based to some degree on individual user sensitivity.

13. Do not overtighten the interpupillary lever clamp (on PVS-5). On ANVIS the eye span adjustment knob is self-locking and the user should note eye span setting for future use.

14. Tighten the clamp knob (PVS-5). Do not overtighten, as this may result in damage to the NVG plastic housing. No similar action is required for ANVIS.

18.6.3.2.2 Binocular Focusing. The DAR allows the user to correct for visual deficiencies such as myopia and hyperopia. The range of the diopter adjustments is +2 to -6. The diopter adjustment cannot correct for astigmatism.

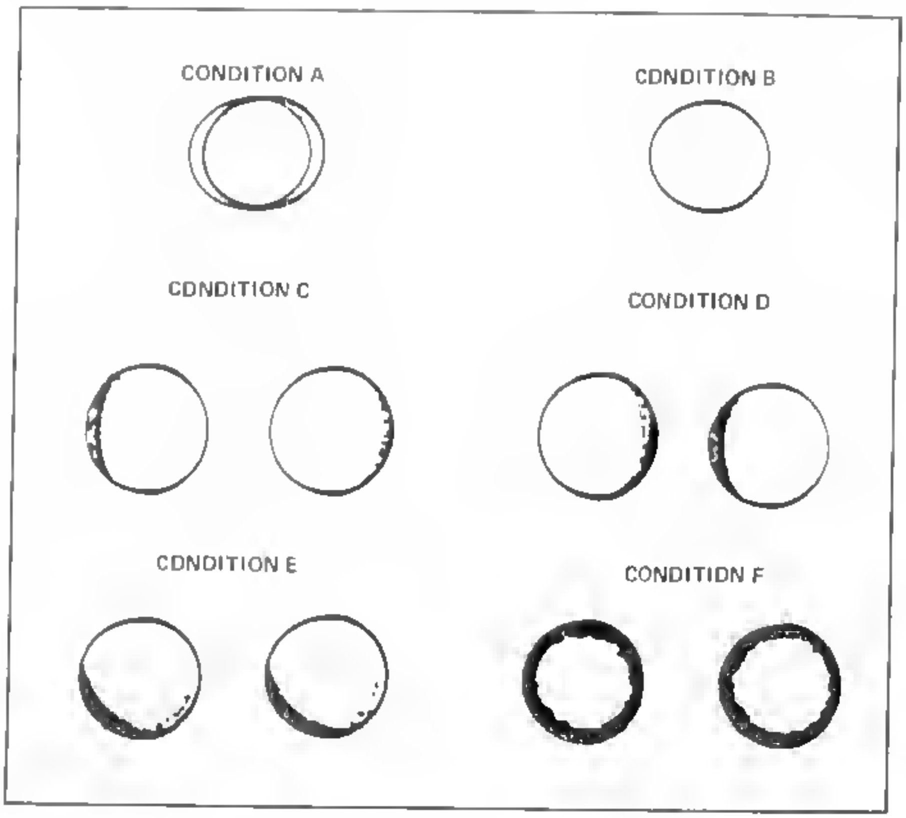


Figure 18-13. Binocular Adjustment Images

When adjusting the DAR, it is possible to achieve a clear image in each monocular, and still have a blurred binocular image. The reason for this apparent dichotomy is that, when the DAR is set for one eye (while the other eye is covered) the eyes will tend to accommodate to a nearer distance than infinity (typically one to three feet). Overaccommodation and/or focus imbalance between the eyes can cause eye strain and periodic blurred vision. To achieve a clear and relaxed binocular focus, the following sequence should be followed, after IPD has been properly set.

1. Set both focus knobs for infinity and view distant objects (beyond 100 feet) such as trees or other prominent features. Artificial lights are generally too bright, making determination difficult.

2. Ensure that right and left monocular images are focused by alternately covering the opposite tube or eye. This focus should have been attained in the IPD adjustment.

3. To focus for binocular vision, slightly blur the image in the left tube with the focus knob (not the DAR). The image should be blurred enough to deny fine detail recognition without losing object shapes.

(*Or the right; the sequence described here is purely for text clarity.)

4. Keeping both eyes open, adjust the right DAR for the clearest attainable image.

5. Return the left focus knob to infinity and slightly blur the image in the right tube with the focus knob.

6. Keeping both eyes open, adjust the left DAR for the clearest attainable image.

7. Return the right tube's knob back to infinity.

18.6.3.3 Common Adjustment Malfunctions

1. Rotation difference — during or after making the adjustments for IPD and binocular focusing, one monocular may become misadjusted (inadvertently twisted). The NVG should not be utilized until this condition is corrected.

2. Luminous difference — during or after making the adjustments for IPD and binocular focusing, one image may appear less luminous (dimmer) than the other. This is an indication of a defective tube and the NVG should not be utilized until the condition is corrected.

3. Contrast difference — during or after making the adjustments for IPD and binocular focusing, the two images may differ in contrast. In a contrast comparison, the user is looking for noticeable differences in the range between the darkest and lightest portions of an image. For example, if a highly reflective tree is extremely bright in one tube, and relatively dim in the other, contrast differences may be deemed unacceptable for that set of NVG. This may also be indicative of a defective tube, however, the degree of the deficiency will not automatically dictate that the goggles not be used. As dictated by ambient light levels, terrain, user experience, and degree of tube differences, the user may elect whether or not to utilize the NVG for a given mission. Obviously, the first available opportunity should be taken for submitting the effected goggles for repair after the mission.

18.6.3.4 IR Illuminator. The IR illuminator was designed to aid in close-in viewing when using full face PVS-5. The MFP has made this unnecessary, and in most cases the illuminator is no longer operational. If installed, operational, and inadvertently left on, the illuminator can significantly degrade goggle performance. After the NVG has been donned, a check to ensure that the IR illuminator has not been inadvertently turned on can be accomplished by passing a hand in front of the goggles. If the contrast appears brighter, the illuminator is on. Turn the three-position rotary switch to the *off* position.

18.6.4 ANVIS/PVS-5 Tube Fault Checks

18.6.4.1 ANVIS Test Set Checks. The Avionics Maintenance Plan for ANVIS (AVMP-0509 Rev. C) published by NAVAIR 41022E states that at the organizational level, scheduled maintenance should include system operational checks utilizing the ANVIS test set to assure proper operation prior to aircrew use. This may prove difficult to accomplish because of the shortage of available test sets. What the Army has done, as an interim measure, has been to conduct comparative testing. One set of NVG will be evaluated on a test set and used as the reference set for comparison of visual acuity and resolution with the sets that will be used for flight. If a test set is available at the squadron level, the following checks should be accomplished prior to flight.

18.6.4.1.1 GO and/or NO-GO Test. This test checks for binocular current drain.

18.6.4.1.2 Tube Stability Test. This allows the user to test the image intensifier tubes for the following malfunctions.

1. Shading (Condition A, Figure 18-14) — shading is that condition encountered when a full circular image cannot be attained in a monocular. The condition will always begin on the edge of the image and move inward. Shading usually comes about as a result of a shift in the microchannel plate (MCP) caused by the goggles having been dropped or otherwise handled roughly. If shading is present in either tube the binocular should be turned into IMA for repair.

2. Edge glow (Condition B, Figure 18-14) — edge glow might also be the result of a shift in the MCP because of mishandling. Like shadowing it will appear in the outer portion of the image viewed appearing as a bright border in a segment of the viewed image. To ensure that the bright segment viewed in the image is edge glow and not a result of a bright light in the goggles' field of view, the hand should be cupped over the tube to block out all light. If the edge glow is still visible, turn in the binocular to IMA.

3. Bright spots and/or dark spots (Condition C, Figure 18-14) — bright spots (sometimes referred to as white dots) and dark spots are actually the same condition in early and later phases (respectively). The spots occur as a result of irregular emission points on the photocathode of the image intensification tube. In the early stages (white dot) the spots may appear constant, or occasionally flicker. In time the white dots turn to dark spots as electron saturation literally "burns through" the photocathode. Neither condition necessarily means that a tube is unusable. As long as the pilot is comfortable with the amount of remaining image in the affected tube, the monocular is acceptable.

4. Honeycomb pattern (Condition D, Figure 18-14) — a honeycomb pattern across the tube image is not an indication of tube fault, it is rather a condition that occurs when too much light enters in through the objective lens. The honeycomb pattern is literally a reflection of the MCP. Removing the goggle from the high light level environment should eliminate the condition.

5. Flashing, flickering, or intermittent operation — these indications may reflect an impending failure in the monocular, faulty wiring, or impending battery failure. If replacing the battery does not alleviate this condition, turn the system in to IMA.

18.6.4.1.3 High Light Resolution Test. This test evaluates the NVG's capability to perform in high light level conditions.

18.6.4.1.4 Low Light Resolution Test. This test evaluates the NVG's capability to perform in low light level conditions.

18.6.4.1.5 Objective Lens Infinity Focus Check. This test checks to ensure that the infinity focus of both objective lenses are within 1 and/or 2 ridge of the stop.

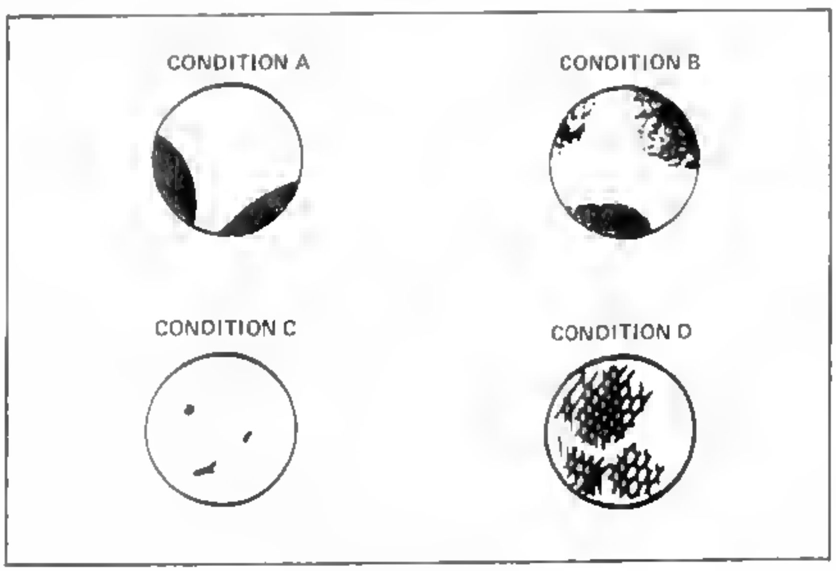


Figure 18-14. Tube Faults

18.6.4.1.6 Eyepiece Zero Diopter Setting Check. This test checks to ensure that the diopter setting of the monocular under test is 0 diopter.

18.6.5 NVG Operational Considerations in Adverse Environments. Sandy and/or dusty areas, rainy or humid conditions, saltwater environments, and arctic conditions all call for special considerations to protect the NVG lenses, circuitry, and delicate mechanisms. The following procedures are recommended:

18.6.5.1 Dusty or Sandy Areas

1. Exposure of the objective lens in particular to blowing dust or sand may scratch them and seriously degrade the goggles' performance.

2. Keep the carrying case closed when not removing or replacing items.

3. Ensure that all dust and sand is removed from the binoculars, mount power pack, and carrying case after operation.

4. When using lens paper ensure all sand has been cleaned from the lenses to avoid lens damage.

18.6.5.2 Rainy, Humid, or Arctic Conditions

1. Keep the carrying case closed when not replacing or removing items.

2. Dry off parts and surfaces after exposure to rain or high humidity.

3. Do not store any part of the NVG systems in a wet carrying case.

18.6.5.3 Saltwater Areas. After operations in a saltwater environment, the following steps should be followed:

1. Clean all hardware thoroughly with a clean soft cloth dampened with fresh water.

2. Separate and individually clean the binoculars and all mounting hardware attached to the helmet. Do not immerse in water.

3. Carefully inspect for corrosion on the electrical contacts.

4. Clean as described in the general care and cleaning section to follow.

18.6.6 General Care and Cleaning. To ensure the continued, reliable performance of the NVG, careful adherence to the following care and cleaning procedures should be observed.

18.6.6.1 Cleaning

1. Gently brush off all dirt with a soft lint-free cloth.

2. Moisten the cloth with clean fresh water and gently wipe external surfaces free of foreign material.

3. Dry with another clean, dry soft cloth.

4. Carefully remove all loose dirt from lenses with lens paper only.

5. Lightly and slowly wipe the lenses with a dampened piece of lens paper.

6. Repeat these procedures until the glass surfaces are clean.

7. Store NVG in a clean and dry carrying case.

18.6.6.2 Additional Care Considerations

1. Lens caps should be installed on the NVG when not in use.

2. When installing or removing a battery, ensure that the selector switch is in the *off* position. If the switch is on, intermittent electrical contact is made when removing or replacing the battery cap. This may cause a power surge in the system that can result in burn spots on the tubes.

3. Always remove the battery from the goggles or power pack. If the devices are stored with the battery installed, corrosion may develop.

4. Loosen all adjustment knobs and levers before placing the NVG in the carrying case (PVS-5 only).

18.7 LASER AND NIGHT VISION GOGGLES

NVG intensifier tubes are sensitive from 0.35 to 1.0 micron for second-generation goggles, and 0.62 to 0.98 microns for third generation. Lasers that will affect these are the continuous wave green Argon (0.511 microns), the pulsed green Double Neodymium (0.532 microns), the pulsed red Ruby (0.694 microns), as well as near infrared Alexandrite (0.76 microns). As can be expected, PVS-5 is affected by all visible and near infrared lasers, while the ANVIS is not nearly as susceptible to the Argon and Double Neodymium. The reason for this comparable immunity is the minus blue

filter on the objective lens assembly of the AN/AVS-6 system.

18.7.1 Continuous Wave Effects. Continuous wave laser in-band effects on NVG approximate that of conventional light. Tubes will degain, bloom, *shut down*, and, in extreme cases, incur immediate damage. In spite of the damage to the device, however, NVGs do afford protection to the aircrew from the laser, in that they will protect the sensitive central field of view of the eye. Pulsed laser in-band effects of NVG would probably include rapid damage to the device, without the pilot perceiving any *warning* (bloom, etc.). Out-of-band CW effects could be expected to produce effects similar to in-band effects, but will require much higher power levels and extended exposure times to do so. Pulsed lasers, with their associated power levels, can be expected to produce greater out-of-band effects than continuous wave.

18.7.2 Laser Protection. There are, in fact, two types of protection over which we must concern ourselves: protection as it pertains to the user's eyes, and as it pertains to the NVG device. As previously mentioned, NVGs provide an automatic degree of protection to the user in that his central field of view is protected. This protection is provided by the internal structure of the intensifier tube acting as a mechanical stop against the laser. There is no automatic provision, however, to protect the aircrewman's peripheral vision. Laser spectacles are currently being devised that may fit behind the NVG and will provide this type of peripheral protection, but certain compatibility difficulties must be worked out before these find widespread use among aviators. Laser protection for the NVG themselves is also possible with the introduction of filter caps on the front of the image intensifier tubes. Significant trade-offs take place with the introduction of these, however, when they limit the amount of light taken into the goggle's objective lens.

CHAPTER 19

Night Vision and Night Vision Goggles (NVGs)

19.1 INTRODUCTION

This chapter contains information concerning the physiological factors of night vision, dark adaptation considerations, night vision techniques, visual illusions and spatial orientation problems, and the techniques of terrain interpretation at night. The following information is a paraphrased abstraction of portions of the Department of the Army Training Circular 1-28 (TC 1-28), Rotary Wing Night Flight. It is presented in this manual to assist the pilot in developing his night flying skills by acquiring a comprehensive understanding of the problems of perception inherent in night tactical flight operations.

19.2 NIGHT VISION AND THE UNAIDED EYE

Of all the sensory means that an aviator uses in flight, his eyes are the most important. He needs good depth perception for safe landings and takeoffs, and good visual acuity for identifying terrain features and obstacles which lie along the flightpath. When flight is conducted during daylight hours, the eyes are capable of appreciating these visual cues; however, during hours of darkness, illumination is reduced and the unaided eyes are limited as to what can be seen. Flight personnel who have 20/20 day vision may not possess an adequate night vision capability. This may be caused by a physical deficiency or a self-imposed limitation (e.g., smoking). It is important that the aviator be aware of his deficiencies and limitations before conducting night flight. Avoidance of self-imposed limitations will assist the aviator in achieving good night vision.

Laboratory tests have proven that having an aviator with good night vision does not automatically guarantee the most effective use of this capability. An untrained aviator may find it difficult to identify an object at night; however, the eye, like the mind and hand can be trained. Although the limits of night vision vary from person to person, experience shows that most aviators have never learned to use their night vision to its fullest capacity. An aviator with an average night vision capability who knows techniques of night vision is far better off than an aviator with superior night vision who doesn't know *how to see.*

19.2.1 Anatomy and Physiology of the Eye. The eye functions similar to a camera and consists of two main parts:

1. The cornea, lens, and iris combination gathers and controls the amount of light that is allowed to enter the retina.

2. The retina can be compared to a photographic film. It is a sensitive layer upon which the light is focused to form an image.

The visual center of the retina is called the fovea centralis. It contains only cones which operate most efficiently at ordinary illumination such as those that prevail throughout the day and in normally lighted rooms at night. Cones provide for the perception of color and the ability for the normal individual to see clearly, sharply, and precisely with 20/20 or better visual acuity. Because the cones are more concentrated in the center of the retina, central vision is the most acute. As light levels are reduced, normal color vision becomes less reliable and finally disappears. Runway light colors can be identified because the light is of sufficient intensity for the cones to perceive color. If the color of an object or terrain feature is to be recognizable at night, it must be illuminated by a white light with sufficiently high intensity to permit cone perception of colors.

During darkness or with low-level illumination, central vision becomes less effective when a relative blind spot (5° to 10° wide) develops. As a result of the fovea's exclusive cone representation, the absolute blind spot is from 2° to 2.5° wide. However, since the area immediately around the fovea is predominated to cones, it too is relatively insensitive. Thus, the functional or operational blind spot affects an area from 5° to 10° wide to the center of the visual field. This results from the relatively light insensitive elements concentrated in the area immediately surrounding the retina of the fovea centralis. Once the central fields of vision for each eye are superimposed for binocular vision, we can speak of a single night blind spot for the normal man. The night blind spot should not be confused with the day blind spot. The day blind spot results from the optic disc's position on the retina. The optic disc is devoid of light sensitive receptors. However, due to the overlap of binocular vision, the day blind spot is not noticed. The night blind spot is centrally located. As a result, it is noticed even when both eyes are used. Each eye has an identical night blind spot so that viewing with one eye closed would produce the same limitation as binocular vision except that the day blind spot would also become apparent. If an object is viewed directly, it may not be detected due to the blind spot; if detected, it will fade more rapidly. As a result of the projected central blind spot, larger and larger targets will be missed with increasing distance. The use of the word projected is used figuratively in that the effect of the blind spot is as if it were being projected like a ray of blindness, obscuring larger areas with increasing distance from the viewer.

The remainder of the retina contains rods and cones with rods increasing in relative number toward the periphery. As previously stated, the central retina is capable of highly acute vision in high illumination due to the concentration of cones. This peripheral retina is almost exclusively associated with rods. Rods perceive only shades of gray. Because of the way they are connected to the brain, they only perceive form or shape; therefore, peripheral vision is less precise than central vision. However, rods are about 1,000 times as sensitive to light as cones. They are the primary visual receptors in dim illumination and thus mediate night vision. Greatest sensitivity of the rods is achieved after a total of 30 to 45 minutes. Exposure to light sources tends to bleach out the rods and reduces the night vision capability of the rods. Because visual acuity is reduced at night, object and target recognition is often limited to silhouette forms.

19.2.2 Dark Adaptation. Dark adaptation is the process by which the eyes increase their sensitivity to low levels of illumination. Rhodopsin (visual purple) is the substance in the rods responsible for light sensitivity. Dark adaptation occurs as the amount of visual purple in the rods increases through biochemical reactions. This may be accomplished to varying degrees and at different rates. In a darkened theater the eye adapts rather quickly to the prevailing level of illumination, which, compared to the characteristics of a moonless, starlit night, is rather high. Less time is required to adapt from the greater illumination level to complete darkness than from the high level of brightness in hangar interior. Thus, the lower the starting level of illumination, the more rapidly complete dark adaptation is achieved. Dark adaptation for optimum night visual acuity approaches its maximum level in approximately 30 to 45 minutes under minimal lighting conditions.

If the dark-adapted eye is carelessly or inadvertently exposed to a bright light while in flight, the sensitivity of that eye is temporarily impaired. The amount of impairment depends on the intensity and duration of the exposure. Brief flashing from a white (Xenon) strobe light of high intensity will have a minimum effect upon night vision because the pulses of energy are of such short duration (milliseconds); however, continuous exposure, particularly under undesirable conditions (haze, clouds), will cause a distraction that would reduce a pilot's ability to conduct night flight. Exposure to a flare or a searchlight beam which would normally be for a period in excess of 1 second could seriously impair the aviator's night vision. Depending upon the brightness and duration of such an exposure, the recovery of a previous maximum level of dark adaptation could take from 5 to the full 45 minutes in continued darkness.

Exposure to bright sunlight has a cumulative and adverse effect on dark adaptation. This condition is intensified by reflective surfaces such as sand and snow. Aviators exposed to intense sunlight for 2 to 5 hours will experience a definite decrease in daylight visual sensitivity which can persist for as long as 5 hours. In addition, the rate of dark adaptation and the degree of night visual capacity will be decreased. These effects are cumulative and may persist for several days.

The retina rods are least affected by the wave length of a dark red light source (wave length longer than 620 millimicrons). Because the rods are stimulated so slightly, night vision is not significantly

impaired when viewing red lights of the proper wave length. The intensity and duration of preexposure to this light source determines the degree to which night vision is affected.

19.2.3 Protection of Night Vision. Aviators who are required to conduct night missions should wear military neutral density sunglasses or equivalent filter lenses when exposed to bright sunlight. This precaution will minimize the rate of dark adaptation at night and improve night visual sensitivity.

Red lights should be the only source of lighting in the cockpit. The intensity of the cockpit lights should be adjusted to the lowest level which will allow the pilot to interpret the instruments. Lights which are not mission essential may be extinguished.

Wearing approved red-lens goggles prior to the execution of a night operation allows the aviator to begin his dark adaptation in an artificially illuminated room and decreases the possibility of undesirable effects from accidental exposure to bright lights, especially when going from the briefing room to the flight line. The wearing of red-lens goggles, however, does not provide a good dark adaptation as does complete darkness for 30 to 45 minutes. When the mission permits, flight should be conducted in an area away from bright ground lights to allow sufficient time to achieve maximal dark adaptation prior to conducting an approach to minimal lights or low-level flight.

When conducting night operations from a fixed airfield, precaution should be taken to eliminate light sources which may impair the aircrew's dark adaptation. To ensure a better operating environment for an aircrew performing night missions, the following precautionary measures should be implemented:

1. Aircraft scheduled for night flight should be positioned on the airfield where the least amount of light exists.

2. Light discipline should be practiced by maintenance and service crews.

3. To permit taxi operations without bright lighting, taxi lanes cleared of obstacles should be established and marked with minimal lighting (preferably red).

4. Airfield lighting should be reduced to the lowest intensity.

5. Departure routes should be selected to avoid highways and residential areas where artificial illumination could reduce the aircrew's night vision.

During the conduct of a night tactical air mission, the aircrew can expect to experience battlefield and meteorological conditions (e.g., artillery flashes, flares, searchlights, lightning, etc.) which will cause total or partial loss of their night vision. When confronted with these conditions, the aircrew can apply the following techniques:

1. If a flash of high intensity light is expected from a specific direction, crewmembers should turn the aircraft to minimize exposure to the light source. When such a condition occurs unexpectedly and direct view cannot be avoided (e.g., lightning) dark adaptation can be preserved by covering or shutting one eye while using the other to observe. Once the light source is no longer a factor, the eye which was covered will provide the night vision capability required to conduct flight. This is possible because dark adaptation occurs independently in each eye.

CAUTION

Difficulty will be experienced with depth perception or orientation outside the cockpit when viewing with the remaining dark-adapted eye, particularly when flying near terrain obstacles or in the course of an approach to landing. Under such circumstances, altitude or distance should be maintained or increased until orientation is stabilized and assured.

2. Flight routes should be selected to avoid built-up areas where a heavy concentration of lights would be encountered. If these conditions are inadvertently encountered, the flight route should be altered to avoid overflight of the brightly illuminated area. Loss of dark adaptation from a single light source such as a farmhouse or an automobile can be avoided by turning the head and eyes away from the light.

3. When flares are being used to assist in a night tactical operation or if they are inadvertently detonated above your position, the aircraft should be flown as close to the periphery of the illuminated area as possible. Also, the pilot should maneuver the aircraft so that his position will be on the opposite side of the light source. This procedure prevents direct observation of the flare by the pilot.

4. Ordnance can be fired in almost any combination without serious impairment of night vision so long as the weapon flash is of short duration and the aircrew avoids looking directly at the flash.

Night vision is dependent upon optimum function and sensitivity of the rods of the retina. Lack of oxygen to the rods (hypoxia) significantly reduces air sensitivity and causes an increase in the time required for dark adaptation and a decrease in the ability to see at night. Without supplemental oxygen, a measurable decline in night vision is evident at all pressure altitudes in excess of 4,000 feet. For this reason, it is recommended that oxygen be used when operating above a pressure altitude of 4,000 feet (i.e., mountain operations where the mean elevations exceed 4,000 feet).

19.2.4 Self-Imposed Stresses. There are limitations to night vision which are self-imposed by aviation personnel. An awareness of these self-imposed restrictions is essential to ensure that each is avoided before participating in night flight.

19.2.4.1 Smoking and Night Vision. Cigarette smoking significantly increases the amount of carbon monoxide carried by the hemoglobin of red blood cells, thus reducing the blood's capacity to combine with oxygen. Hypoxia from carbon monoxide poisoning affects night visual sensitivity and dark adaptation in the identical way and to the same extent as hypoxia resulting from high altitude. Smoking three cigarettes in rapid succession or 20 to 30 cigarettes per day may saturate from 8 to 10 percent of the capacity of the hemoglobin of the red blood cells in the body. The physiological effect of this condition is that the smoker has effectively lost 20 percent of his night vision capability at sea level.

19.2.4.2 Alcohol and Night Vision. Alcohol has the effect of creating sedation, thus causing lack of coordination and impairment of judgment. As a result, the aviator fails to apply the proper techniques of night vision. He begins to stare at objects and his scanning techniques become disorganized. Alcohol, like cigarette smoking, impairs night vision, but to a greater extent. The two in combination are probably cumulative. The degree to which night vision is affected is determined by the amount of alcohol consumed. Hangover aftereffects will also impair visual scanning efficiency.

19.2.4.3 Fatigue and Night Vision. An aviator who is fatigued when performing night missions lacks mental alertness and fails to apply the proper techniques of night vision. He responds slowly to situations which require immediate reaction. He tends to concentrate his attention in one area without consideration for the total requirement. Depending on the degree of fatigue, his performance may become a safety hazard.

19.2.4.4 Sickness and Night Vision. Normally associated with sickness is an increased temperature and a feeling of unpleasantness. High body temperatures consume a higher rate of oxygen than is normally required. As a result, relative hypoxia is induced and degradation in night vision may occur. In addition, the unpleasant feeling that is associated with sickness distracts the aviator's attention and restricts his ability to concentrate on night flying requirements.

19.2.4.5 Nutrition and Night Vision. Failure to eat foods that provide sufficient vitamin A could cause impairment of night vision. Foods that are high in vitamin A content are eggs, butter, cheese, liver, apricots, peaches, carrots, squash, spinach, peas, and all types of greens. An adequate intake of vitamin A is normally provided by a balanced diet. Note that excess quantities of vitamin A will be of no additional help and may be harmful. Stomach contractions (hunger sensations) from missed or postponed meals appear to exert a most unpleasant effect and could conceivably cause distraction, breakdown in habit pattern, shortened attention span, and other psychological traits.

19.2.4.6 Physical Conditioning and Night Vision. Because of the physiological stresses of night flight, the aviator becomes more easily fatigued. To overcome this limitation, aircrew members should participate daily in a physical fitness maintenance program. Good physical fitness may help the aviator conduct night flight with less fatigue and might improve his night scanning efficiency.

19.2.5 Night Vision Techniques. Successful dark adaptation is only the first step toward maximizing one's ability to see at night. In order to see effectively in the

dark, an individual must apply night vision techniques which enable him to overcome the previously discussed physiological limitations of the eyes. During daylight hours, objects can be perceived at a great distance with useful detail. At night the range is limited and detail is poor. A sound basic principle of visual scanning, day or night, is to view the predetermined field of vision moving the head and eyes together as a unit. Movement of the eyes, independent of the head (i.e., sideways or vertical) will in some cases reduce the protective overlap provided by a binocular vision or tend to break the stimuli that encourage fusion of the images reaching each eye. Thus, it prevents a tendency or condition in which the eyes might operate independently and cause confusion. Because of these limiting factors and the inability to perceive objects while rapidly sweeping a field of view, a systematic method of scanning must be used.

The technique used by the aviator to view the terrain along the flightpath becomes an important consideration if he is to perceive obstacles and identify terrain features which will ensure safety of flight, accurate navigation, and target acquisition. To scan effectively, the aviator must scan from side to side and from top to bottom of the field of view in 10° overlapping movements. This procedure is repeated continuously throughout the flight. While eye movements will be directed along the central visual axis, it is the peripheral field of vision that will permit detection of an object coming into the field of view. The scanning technique can be compared to a series of aerial photographs. All the pictures make up a composite of the terrain being viewed. Once the aviator has developed this scanning technique, he must incorporate one additional factor, the rate at which he will scan.

Because of the inability of the light sensitive elements of the retina to perceive images while in motion, the aviator must develop a stop-turn-stop-turn type motion. The time required in the stop portion of the scanning procedure is determined by the degree of detail that is required, but should be no longer than 2 to 3 seconds. This is because the rhodopsin (visual purple) in the rods will bleach out momentarily unless the stimulation is variable in light energy. (Remember that head movements must be limited during turning maneuvers to avoid vestibular illusions such as Coriolis, i.e., vertigo, spatial disorientation.)

Viewing an object using central vision during daylight poses no limitation; however, this same technique at night will result in a loss in the visual acquisition of the object. To compensate for this limitation, off-center vision must be used. This technique requires that an object be viewed by looking 10° above, below, or to either side rather than directly at the object. This allows the peripheral vision of the eyes to maintain surveillance of the object.

The technique off-center vision applies only to surveillance of areas that are minimally illuminated or luminous. Under these conditions, cone vision is not stimulated. If an object or area is just bright enough to be seen by central vision (thus of sufficient intensity to stimulate the cones) and needs to be seen with considerable detail, then central vision is best utilized until the object begins to fade. At this point, the target should be redetected using off-center vision and retained until central vision recovers sufficiently to permit further observation.

Even though off-center vision is practiced, if an object is viewed for a period of time in excess of 2 to 3 seconds, the images tend to bleach out and become one solid tone. As a result, the object can no longer be seen, thus inducing a potentially unsafe operating condition. To overcome the limitation of night vision, the aviator must be aware of the phenomena and avoid viewing an object off-center longer than 2 or 3 seconds per scan. By shifting the eyes from one off-center point to another, the object will continue to be acquired in the peripheral field of vision.

Visual acuity will be significantly reduced at night. Because of this limitation, objects must be identified by their silhouettes. The ability of the aviator to recognize objects using this technique will be determined by the aviator's familiarity with the architectural design of the structures which are common to the area in which the mission is being flown. A silhouette of a building with a high roof and a steeple can be easily recognized as a church in America; however, churches in other parts of the world may have a low-pitched roof with no distinguishing features. Manmade features depicted on the map will also assist in recognition of silhouettes observed while in flight.

19.2.6 Depth Perception With Night Vision. The cues to depth perception are most apparent using central vision under good illumination. As night falls, judgment of depth perception decreases. One night seeing eye is less precise as a distance measuring device and can be subject to illusions as well. A knowledge of the

mechanisms and cues to depth perception will assist the aircrewman in making a better judgment of distance at night.

19.2.6.1 Estimation of Distance. There are numerous mechanisms and cues that can be used to judge distance. An estimation of distance in a situation can be derived by using only one mechanism or by using a combination of several mechanisms and cues. These estimations are usually derived on a subconscious level; that is, without the individual being in a given situation, he may look for or be aware of additional cues beyond those which he would habitually use, and thus form a more accurate estimation of distance. These cues to distance or depth perception are monocular or binocular. Monocular means that only one eye is required for judgment. The binocular cues depend on the slightly different view each eye has of the object. Consequently, binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of the two eyes.

In flying, most of the distances exterior to the cockpit are so great that the binocular cues are of little if any value. In addition, these cues operate on a more subconscious level than the monocular cues, and are thus not as capable of being improved by study and training. Therefore, binocular cues will not be discussed.

19.2.6.2 Depth Perception — Monocular Cues

19.2.6.2.1 Geometric Perspective. An object has an apparent different shape depending on the distance and angle from which it is being viewed. Types of geometric perspective are:

1. Linear perspective — parallel lines such as railroad tracks tend to converge as distance increases from the observer.

2. Apparent foreshortening — the true shape of an object or terrain feature appears elliptical when viewed from a distance. As the distance to the object or terrain feature decreases, the apparent perspective changes to its true shape or form.

3. Vertical position in the field — objects or terrain features which are farther away from the observer appear higher on the horizon than objects or terrain features that are closer to the observer.

19.2.6.2.2 Motion Parallax. This cue to depth perception is often considered the most important. Motion parallax refers to the apparent relative motion of stationary objects as an observer moves across the landscape. Near objects appear to move backward, past, or opposite the path of motion and far ones seem to move with it or remain fixed. When one fixes upon a near object, distant objects tend to move in the same direction as the observer. The rates of apparent movement depend on distance from the observer — objects near the aircraft move most rapidly, while distant objects appear to be almost stationary. Thus, objects that appear to be moving rapidly are judged to be near and those moving slowly are judged to be distant.

This can be readily appreciated from the reader's position if he looks at his surroundings. When the line of sight is fixed and maintained on one object while the position of the head is changing, other objects which appear to move in the same direction as the movement of the head are judged more distant while objects moving in the opposite direction are nearer than the object on which the line of sight is fixed.

When an individual drives along a road, the fence pickets near the roadside rapidly whiz by. A tree not far from the roadside passes more slowly. Mountains in the distance and the moon appear to be fixed or moving with the vehicle and its occupant.

19.2.6.2.3 Retinal Image Size. The size of an image focused on the retina is perceived by the brain to be of a given size. The nearer an object is to us, the larger is its retinal image. By experience, the brain learns to associate the distance of familiar objects by the size of their retinal image. A church building is seen at an unknown distance. It may be 30 to 40 feet tall. If its height subtends a small angle on the retina, the observer judges, usually subconsciously, that the building is at a great distance. A large angle would be judged by the observer as the building being close in to the aircraft. To utilize this cue, one must know the actual size of the object and have prior visual experience with it. If no experience exists, an object's distance would be determined primarily by motion parallax. If the retinal image size of an object increases, it is retreating or moving farther away; if constant, it is a fixed distance. Comparison of an object such as an airfield in the distance with an object of known size, configuration, and alignment, such as a helicopter, will help to determine its relative size and apparent distance. Objects ordinarily associated together are judged to be at approximately the same

distance. A helicopter is seen at a great distance making a slow turn. An airport is seen in approximately the same direction. The helicopter is judged to be in the traffic pattern and therefore at approximately the same distance to the field.

19.2.6.2.4 Overlapping of Contours or Interposition of Objects. When one object is seen to overlap another, the object which is being overlapped is farther away. Otherwise stated, an object partly concealed by another object is behind it.

19.2.6.2.5 Aerial Perspective. Colors or shades fade with distance. Large objects seen indistinctly are judged to have a considerable amount of haze, fog, or smoke intervening, and therefore appear to be at a great distance. If atmospheric transmission of light is less than expected, the distance is overestimated; if greater than expected, the distance is underestimated. A cargo helicopter is larger than an attack helicopter but because of a difference in viewing distance and size, let's assume they both subtend the same angle on the observer's retina (their retinal image sizes are equal). Therefore, from this cue alone, assuming no previous experience with the appearances, they appear the same size. However, if the cargo helicopter is seen less distinctly because of visibility restrictions, it would be judged to be a greater distance away and larger than the attack helicopter.

As distance increases there is a loss of discrimination or texture. As one draws nearer to an object, more discrete details become apparent; e.g., a green field develops blades of grass, a tree develops leaves and branches, and an animal becomes a steer rather than a cow. If a shadow is seen nearer the observer than an object, the object is nearer than the source of light.

19.2.7 Visual Illusions. With decreasing visual information, there is an increased probability of spatial disorientation. The cause for spatial disorientation because of the loss of visual reference may be a composite of several illusions. A few important visual illusions occurring in the aviation environment are:

19.2.7.1 Autokinesis. Autokinesis, or the autokinetic illusion, is the illusory phenomenon of movement which a static light exhibits when stared at for a long time in the dark. This phenomenon can be readily observed by taking a lighted cigarette into a completely dark room and staring at it until it appears to move. The apparent movement will begin after approximately 8 to 10 seconds. The cause is not known for certain, but appears to be related to the loss of surrounding structural references which normally serve to stabilize or anchor our visual perceptions. This illusion can be eliminated or reduced by visual scanning, by increasing the number of reference lights, or by continuously varying the light intensity. The most important of the three is visual scanning technique. A target of light or lights should be fixated for periods no longer than 10 seconds. A fixed object, such as an instrument panel top, should be used as a reference from which an observer may scan. This illusion is not exclusively limited to lights in darkness. It can occur whenever a small, bright, still object is stared at against a dull, dark, or indescript background. Similarly, it can occur when viewing a small, dark, still object against a light, structureless environment. Place a pink-colored dot about 3 inches in diameter on a large chalkboard. Stare at the dot. Eventually it will move. Flying over still water towards a boat could produce such an illusion. Fixing on a marker in the snow day or night could produce similar results.

19.2.7.2 Confusion of Ground Lights With Stars. Many aviators have put their aircraft into very unusual attitude in order to keep some ground lights above them, having mistaken them for stars. Some aviators, for example, have misinterpreted the lights along the seashore as being the horizon, and maneuvered their aircraft dangerously close to the sea while under the impression of flying straight and level. Aviators have also confused certain geometric patterns of ground lights with a runway or identified ground lights as airborne targets.

19.2.7.3 Relative Motion. The illusion of relative motion is similar to a person sitting in a car at a railroad crossing waiting for a train to pass — though the train is actually moving, the person in the car has the sensation that he is moving. This is often encountered by the aviator during formation flying. He sees motion of his wingman or leader and interprets it as motion of his own. The only way to manage this illusion is for the aviator to have sufficient experience to understand that such illusions do occur and not to react to them on the controls.

19.2.7.4 Reversible Perspective Illusion. An aircraft may appear to be departing when it is in fact approaching. This illusion is often experienced when a visually acquired aircraft is turning toward or away from your path of flight. Part of this phenomenon may be due to relative motion.

19.2.7.5 False Horizons. The illusion of false horizons is experienced when an object other than the actual horizon is interpreted to be horizontal to the horizon. For example, an airplane flying between two cloud banks may be flown in relationship to the lower cloud bank because the aviator feels that the lower cloud bank is horizontal to the horizon. In actuality, the lower cloud may be at an angle to the horizon. The aviator tends to level the aircraft in reference to the cloud which puts the aircraft in a turn.

19.2.7.6 Altered Planes of Reference. The pilot of an aircraft approaching a line of mountains or clouds sees the illusion of a need to climb even though altitude is adequate to clear. The reverse is true when leaving such a line. In flying parallel to a line of clouds, there is a tendency to tilt away.

19.2.7.7 Depth Perception Illusion. Day and night flying over desert, snow, or water are characterized by a lack of adequate depth cues. This results in poor or diminished depth perception and, consequently, potentially dangerous situations. Flying into haze or fog at night can produce the same illusion of depth perception.

19.2.7.8 Flicker Vertigo. Much time and research have been devoted to the study of flicker vertigo. It has been demonstrated that a light flickering at a rate of between 4 and 20 cycles per second can produce unpleasant and dangerous reactions. These include nausea, vomiting, vertigo, and on rare occasions, convulsions and unconsciousness. Fatigue, frustration, and boredom tend to intensify these reactions. The problem can be caused by the flickering of the rotating beacons as reflected against an overcast sky.

19.2.7.9 Fascination (Fixation) In Flying. Fascination is said to occur when a pilot for one reason or another ignores orientation cues while his attention is focused on some other object or goal. Target hypnosis is a common type of fascination and is characterized by an incident that occurs when a pilot becomes so intent upon hitting his target during a gunnery run that he neglects to pull up in time to prevent crashing into the target.

19.2.7.10 Structural Illusions. Structural illusions are caused by heat waves, rain, snow, sleet, or other disturbances of the air media through which we see. For example, a straight line may appear curved as seen through the heat wave of the desert. As seen through slanting rain or sleet, a single wingtip light may appear to the pilot as a double light or in a different location.

19.2.7.11 Size-Distance Illusion. The size-distance illusion results from staring at a point of light which approaches and recedes from the observer. In the absence of additional distance cues, accurate depth perception is extremely difficult. Instead of seeing the light advancing or receding, the pilot has the illusion that it is expanding and contracting at a fixed distance from him. This illusion may also be dispelled by continually shifting the gaze.

19.2.8 Meteorological Conditions and Night Vision. Although a flight originates during conditions of clear skies and unrestricted visibility, meteorological conditions may deteriorate during flight. Because of reduced vision at night, the gradual encounter of clouds can easily go undetected. During the initial buildup of cloud formations, difficulty will be encountered in detecting airborne objects because of the lack of contrast between the cloud and aircraft. Inadvertent entry into clouds may occur without warning. At low altitudes the encounter of ground fog and haze can be expected. The loss of visibility can be a gradual deterioration or a sudden encounter. Because detection of adverse weather is difficult at night, the aviator should maintain a constant awareness of changing conditions. The following conditions serve as indicators in the detection of adverse weather conditions at night:

1. A gradual reduction in the available ambient light will occur as cloud coverage increases, resulting in a loss of visual acuity and contrast of terrain features.

2. Loss of visual contact with the moon and stars indicates that clouds are present. The degree to which the stars and moon are obscured determines the amount of cloud coverage.

3. Shadows caused by clouds obscuring the moon's illumination can be detected by observing the varying ambient light along the flight route.

4. The halo effect that is observed around artificial lights indicates the presence of moisture or other small particles. As the intensity of these lights decreases, the moisture or particle content increases.

5. The presence of water vapor suspended over water surfaces indicates that the temperature has

reached the dewpoint and that this condition will spread over the ground area.

19.2.9 Principles of Night Vision. A thorough understanding of the anatomy of the eye and the techniques employed to overcome limitations are necessary in order to see in the dark. The principles that have been discussed in this chapter are summarized in the ten commandments of night vision:

1. Dark-adapt before attempting any night duties.
2. Avoid bright lights after dark adapting.
3. Identify objects by total form.
4. Practice blindfold cockpit drill.
5. Keep your windscreen clean, unscarred, and unscratched.
6. Use off-center vision when viewing an object.
7. Do not stare; scan constantly and systematically.
8. Use oxygen when conducting night flight above 4,000 feet MSL.
9. Avoid self-imposed stresses.
10. Keep physically fit.

19.3 TERRAIN INTERPRETATION

19.3.1 General. The ability of the aviator to see in the dark is dependent upon the ambient light level and how well he employs night vision techniques. Both factors are critical for good night vision; however, to effectively identify what is seen, the aviator must know the conditions which affect the visual presentation of natural and manmade features at night. The following paragraphs discuss the factors which affect terrain interpretation at night and the knowledge which must be acquired to compensate for these limitations.

19.3.2 Factors of Terrain Recognition. The likelihood of detecting a natural or manmade feature at night depends primarily on the following factors:

19.3.2.1 Night Vision Techniques. To see effectively during hours of darkness, night vision techniques must be learned and used when conducting night tactical air operations.

19.3.2.2 Ambient Light. Visual acuity improves as the ambient light level increases. Light sources may be natural (e.g., moon, stars) or artificial (e.g., flares, searchlights, cities). The use of artificial light can be on call or planned for a designated hour and minute. Natural light is a function of the moon phasing angle.

19.3.2.3 Object Size. Because visual acuity decreases at night, the ability of the eye to perceive objects that are small becomes difficult if not impossible. Large structures and terrain features such as churches, water towers, and rivers are more easily recognized during hours of darkness. A small object such as a tank would be difficult to identify because it becomes lost in its environment. To overcome this limitation, a longer viewing time and a shorter viewing distance is required.

19.3.2.4 Object Shape. A natural or manmade object can be identified at night by its shape or the silhouette it forms. Familiarization with the architectural design of buildings will assist in recognition of structures at night. Also, shape will assist in identifying objects that are difficult to recognize because of their small size. For example, a tank which could not be recognized because of its relative small size in relation to its environment may be easily recognized when viewed from the side because of its distinctive silhouette. Shape of terrain features also provides a means of identification at night. Open fields which are shown on the map as triangular shaped may provide positive identification when viewed from the helicopter. Landmarks such as a bend in the river or a prominent hilltop provide a distinct shape which aids in terrain interpretation at night.

19.3.2.5 Viewing Distance. Because the viewing angle becomes smaller as the distance from the object increases, objects which are large in size and distinctive in shape may become unrecognizable if viewed from a great distance at night. This, combined with poor depth perception at night, can lead to faulty judgment of size. Also, objects lose form as the viewing distance increases. A church building viewed at a close distance at night will appear as a large structure with a distinctive high roof; however, viewed at a great distance it may resemble a family dwelling. This phenomenon occurs when viewing military targets or terrain features at a great distance. The distance at which interpretation of an object becomes unreliable is also dependent upon the

ambient light level. An object that might be identified by its shape and size at a distance of up to 1,500 meters, during a high light condition, might be unrecognizable at 500 meters during a low light condition.

19.3.2.6 Contrast. Identification of terrain features by contrast is dependent upon the available ambient light, the color and texture of the object being viewed, and its background.

The ambient light level will affect the degree of contrast that exists between objects. The higher the light level, the greater the contrast. This is because the reflectance is a constant percentage of illuminance. Therefore, as the illuminance level increases, contrast on absolute difference between objects increases. Each object possesses a different reflectance due to the nature of its reflective surface. As the ambient light increases, more light is reflected causing a shade change. Objects with a poor reflective surface appear black during low light levels and a dark gray during a high light level. Objects with a poor reflective surface appear black during low light levels and a dark gray during a high light level. Objects or terrain features which possess good reflective quality will appear a much lighter gray under all conditions of ambient light.

The color and texture of an object or terrain feature will affect its reflective quality. This characteristic of an object or terrain feature will aid or detract in identification by contrast. An open field with no vegetation growth which is light in color is an example of an optimum reflective surface. Areas which are covered with dense vegetation provide the worst condition of reflectivity. Seldom is terrain encountered where the extreme of both cases will be found. Knowledge of the reflective quality of objects and terrain features will aid in identification by contrast. Objects and terrain features which are most affected by contrast are:

19.3.2.6.1 Roads. Dirt roads provide excellent contrast between the surrounding terrain and its surface. This is more pronounced where the road is cut through heavily forested areas. Normally, a dirt road will vary in soil texture and color from that of the soil adjacent to the road. This condition further improves the contrast of the dirt road and surrounding terrain. Asphalt roads are difficult to identify because the dark surface reflects very little light which reduces the contrast between the road and surrounding terrain. Concrete highways provide an excellent reflective surface and can be easily identified at night.

19.3.2.6.2 Water. Bodies of water provide very little contrast against a land mass during low light conditions. When viewed from the air, lakes or rivers appear as dark gray in color. As the light level increases, water begins to change in color, contrast increases, and reflected moonlight can be easily detected. When a surface wind exists, the reflection off the water is intensified by the ripples on the surface which further aid in identification. Bodies of water are more easily recognized when viewed from an angle rather than directly overhead.

19.3.2.6.3 Open Fields. Contrast is very poor in cultivated fields. Most crops are of dark color and tend to absorb light. During the harvest or dormant time of the year, the color of the vegetation changes to a lighter color and contrast improves. A recently plowed field may be void of vegetation; however, because of the course texture of the soil which is caused by plowing, light is absorbed and very little is reflected.

19.3.2.6.4 Forested Areas. Heavily forested areas do not reflect light and appear as dark areas at night. Difficulty will be experienced in identifying objects and terrain features because of the lack of contrast. Excellent contrast exists between an open field and a forested area that normally surrounds an open field.

19.3.2.6.5 Desert. The light color of the soil and sparse vegetation growth which is characteristic of desert terrain provide the best condition of detecting objects and prominent terrain features by contrast. Military targets are easily recognized on the desert because of the contrast between dark and light objects. Frequently, camouflage is used to avoid detection. Mountain ranges which abruptly rise from the desert floor can be easily identified because of the dark color of barren mountains as contrasted against the light color of the flat terrain.

19.3.3 Effects of Ambient Light. Reduced light level at night decreases visual acuity which restricts the range at which an object can be identified. Terrain interpretation by size, shape, and contrast becomes difficult. Because of these limitations, flight must be conducted at slower airspeeds. Safety of flight becomes an important consideration. As a result, flight during low ambient light conditions without night vision devices will be conducted at fixed altitudes that ensure adequate terrain and obstacle clearance.

A high light condition improves visual acuity which increases the range at which an object or terrain feature can be identified. Terrain interpretation by size, shape, and contrast becomes very effective. Because obstacles are more easily recognizable and navigation is easier, faster airspeeds can be flown at lower altitudes.

19.3.4 Effects of Flight Altitude

19.3.4.1 High Altitude. When flight is conducted above 100 feet at night, discriminability of objects on the ground progressively decreases as altitude increases. This condition is affected by all levels of ambient light. Contrast between objects becomes less distinguishable and tends to blend together as altitude increases. Terrain definition becomes less recognizable at higher altitudes which increases the difficulty in detecting altitude changes. Distortion of the form of objects becomes apparent because of the change in viewing angle and the distance at which the object is being viewed. All of these conditions increase the difficulty in conducting pilotage navigation.

19.3.4.2 Low Altitude. Discriminability of ground objects increases as the aircraft is flown closer to the ground. In addition, terrain definition and contrast are improved. This allows for better recognition of objects and terrain features which improve the navigational capability of the aircrews. Recognition of terrain features by silhouetting an object against the skyline is an effective means of identification which cannot be used at high altitude. The visual perspective changes is that the area which can be viewed is smaller. The apparent rate of speed increases, which reduces viewing time. Airspeed may have to be reduced to permit more accurate terrain interpretation.

19.3.5 Effects of Moon Altitude

19.3.5.1 Low Altitude. During all phases of the moon when its altitude is low, ambient light is reduced. The light level is further reduced in valleys and on the backside of mountains by the shadows that occur. When low-level flight is conducted toward the moon during high light levels, extreme glare will be experienced. This condition will cause distortion of vision and possible loss of dark adaptation. Recognition of objects or terrain features that are visible along the skyline is improved. Because the shadow cast by an object distorts its true perspective, difficulty in recognizing objects by their form will be experienced.

19.3.5.2 High Altitude. The higher the altitude of the moon, the greater the ambient light condition. An increased ambient light level improves visual acuity and contrast. Shadows which cause distortion of objects and terrain features and loss of ambient light do not occur. The best conditions for terrain interpretation for any phase of the moon exist when the moon is at its highest altitude.

19.3.6 Visibility Restriction. During conditions of reduced visibility, the ambient light level is reduced causing a loss of visual acuity. The onset of visibility restrictions will normally be gradual. Initially, the visual range at which an object or a terrain feature can be identified is reduced, followed by a loss of terrain definition. As visibility becomes more restrictive, night vision may become impaired to the extent that low-level flight should be discontinued. Normally, ground visibility restriction (e.g., fog, haze) can be avoided when flight is conducted above 500 feet. If visibility restrictions are encountered above this altitude, flight should be conducted by reference to instruments.

19.3.7 Effects of Terrain

19.3.7.1 Desert. Because of lack or recognizable terrain features and vegetation growth, navigation is difficult over desert terrain. The texture and color of the soil provides for optimum reflectivity of ambient light and identification of objects by contrast. Desert terrain which includes barren mountain ranges provides more recognizable terrain features because of rapid changes in elevation.

19.3.7.2 Rolling Terrain (Heavy Vegetation). Because of lack of recognizable terrain features, terrain interpretation is difficult. Contrast is good between forested areas and open fields. Rivers and terrain features that are given distinct changes in elevation from surrounding terrain provide the most recognizable natural landmarks for navigation. Dirt roads and farm structures provide the most distinguishable manmade features. Airspeed will normally be slower to improve terrain interpretation. Flight altitude should be as low as terrain obstacles will allow; however, during periods of low ambient light, reduced visual acuity restricts obstacle identification and the flight altitude will normally be higher.

19.3.7.3 Mountains. Terrain identification can be accomplished best where rapid changes in elevation occur (e.g., mountainous areas, silhouetting ridgelines, or other objects with vertical features). Decreased ambient

light can be anticipated in valleys and on the backside of mountains when the moon is low on the horizon. Contrast is poor because of the heavy growth of vegetation and the dark color of the earth that is common to mountain regions. During high light conditions, navigation is made easier by the abundance of recognizable terrain features; however, airspeed will normally be lower in mountainous regions because of rapidly changing terrain which requires corresponding altitude changes.

19.3.8 Effects of Seasons (Winter)

19.3.8.1 Contrast. Contrast improves during the winter because fewer open fields are cultivated, thus resulting in a change of color and texture of farm areas. Contrast is also improved when snow covers the ground. The light color of the snow compared with structures and heavy forested areas enhances terrain interpretations.

19.3.8.2 Foliage. The loss of foliage of deciduous trees and plants during the winter improves interpretation of terrain features. When heavy growths of these trees and plants cover small rivers and streams, identification of these and other terrain features can be made more easily. Plants and grass which cover open fields change in color and improve the contrast between open fields and evergreens. In areas where plants and tree growth is predominantly deciduous, contrast will be reduced and the difficulty of terrain identification increased. Because a tree is barren of foliage, less light is reflected and the difficulty in identifying obstacles when flight is conducted in low level is increased. This condition induces a safety hazard and may require that the helicopter be flown at a higher altitude.

19.3.8.3 Ambient Light. The orbital path of the Moon is closer to the Earth during the winter. At this time ambient light level is higher than at any other time of the year. This improves visual acuity which enhances terrain interpretation.

19.3.8.4 Meteorological Conditions. It can be anticipated that during the winter there will be an increased number of days when cloud coverage and restricted visibility will prevail. Both conditions significantly reduce the available ambient light which has the effect of decreasing visual acuity and increasing the problem of terrain interpretation.

19.3.8.5 Visual Observation. Where conditions of extreme cold and heavy buildup of snow exist, man-made and natural terrain features may be hidden. A road intersection which provides a good navigation checkpoint may be obscured by a snow drift. Identification cannot be made by visual observation, therefore association with other objects or terrain features must be made. A power line, fence line, or a cut through a forested area must be used to locate the road intersection. Small rivers and lakes that are indicated on the map may be frozen and covered with snow and may not be recognizable. Positive identification can only be made by associating the relative position with other terrain features such as a depression, a tree line, or any other distinguishable terrain features.

19.3.9 Effects of Season (Summer)

19.3.9.1 Contrast. During the summer, identification of objects and terrain features by contrast is less effective as compared to the winter season. This is caused by the increased amount of cultivation of open fields and a new growth of foliage on deciduous trees and plants.

19.3.9.2 Foliage. Because of the dense foliage that obscures small rivers and streams, these terrain features will be difficult to recognize. Military targets will also become unrecognizable when located in or near forested areas.

19.4 NIGHT VISION AND NIGHT VISION GOGGLES (NVGS)

Survivability in combat operations is a function of minimizing threat capabilities while maximizing one's own. One way to maximize threat capabilities is through the use of night low-level operations which reduce the probability of detection by visual, electro-optic, or electronic means. Night operations increase the chance of surprise and decrease the chance of detection and weapons engagement by enemy forces. Night aviation operations are placing increased emphasis on night imaging devices which operate in the optical radiation portion of the electromagnetic spectrum. To fly night low-level profiles, the use of these devices requires a thorough understanding of the night environment, to include the relationships between ambient illumination, the terrain, the night imaging device, and the human eye. Each of these is a critical link in the night vision chain. An understanding of their interrelationships requires that each link be thoroughly understood. As one Russian field marshall put

it, "Darkness is a double-edged weapon, and like the terrain, favors the one who best understands and uses it, while hindering the one who does not."

19.4.1 Basics of Light. Light that stimulates the unaided eye or the night imaging device is a form of electromagnetic radiation. This optical energy belongs to the same class of physical phenomena as radio waves, heat waves, x-rays, cosmic rays, etc. (Figure 19-1). Optical radiation, or light, manifests itself in two ways:

1. As particles of energy called photons
2. As waves propagated through a medium.

The particle theory of light provides a description of the emission of light from a source, such as the Moon. Its energy is measured radiometrically against a known standard, or photometrically through perceptions of brightness and color. Radiometric and photometric units are shown in Figure 19-2; however, for the purposes of this manual, only the photometric units will be used.

19.4.1.1 Luminance Versus Illuminance. The most common photometric terms used are illuminance (expressed as either lumens, lux, or foot candles) and luminance (usually expressed as foot-lamberts).

1. Illuminance refers to the amount of light that strikes an object or surface at some distance from a source. An example is the amount of ambient light that strikes the ground from the Moon. This is only one source of ambient illumination and will be expressed as either lux or foot-candles. The exact relationship between lux and foot-candles is shown in Figure 19-2. This is also shown in Figure 19-3 along with various conditions of the day and night sky.

2. Luminance refers to the amount of light reflected or emitted from a surface and is usually expressed as foot-lamberts. An example of luminance is moonlight, which is reflected from certain aspects of the terrain and enables us to see those features. The moonlight striking the ground is illumination, while the light reflected off the terrain enabling us to see it is luminance. The relationship between illumination and luminance yields a ratio (incident light to reflected light) which is called albedo. Most surfaces have different albedos, so while illumination from the Moon may remain constant, luminance from different terrain sources varies at night. This is why the features of a blacktop road are more difficult to see than the features of a light-colored concrete road. In summary, ambient light sources provide illumination or illuminance, but what our eyes see, and night imaging devices detect is the light reflected from objects and terrain, or luminance.

19.4.1.2 Light Propagation. Illumination and luminance are characteristics associated with the particle or photon theory of light. The wave theory, on the other hand, is particularly successful in describing the various phenomena having to do with the propagation of light through a medium (air) or optical system (the human eye). Regarded as a form of wave motion, light has the characteristics of wavelength, frequency, and velocity. For the purposes of this manual, only wavelength will be considered.

All night imaging devices and the human eye are sensitive to different wavelength ranges of electromagnetic radiation, just as radio receivers selectively tune within a broad spectrum of electromagnetic energy. Referring to Figure 19-4, optical radiation is seen as a relatively small portion of the entire spectrum that includes visible light (0.4 to 0.7 micron) and the near infrared (0.7 to 3.0 microns) which is invisible to the human eye. Although the eye is only sensitive to the light between 0.4 and 0.7 micron (which progresses from purple to blue, green, yellow, orange, and red) a substantially higher degree of light energy exists outside the limits of visible light (especially at night) in the near infrared region (Figure 19-4). It is in this near infrared region that the NVGs are most sensitive.

19.4.2 Night Sky Illumination. There are many sources of ambient illumination that combine to light the night sky. Natural sources include the Moon, stars, solar light, and other background illumination. There are also artificial sources, which include lights from urban areas, automobiles, fires, weapons, searchlights, and flares. Keep in mind, this illumination includes only light that strikes objects or terrain to be observed. It does not include luminance reflected off objects or terrain, which will be discussed later in this chapter.

19.4.2.1 Moon. At night the Moon provides the highest percentage of ambient illumination. Moonlight is actually nothing more than reflected sunlight and although the Moon appears bright to the unaided eye, it

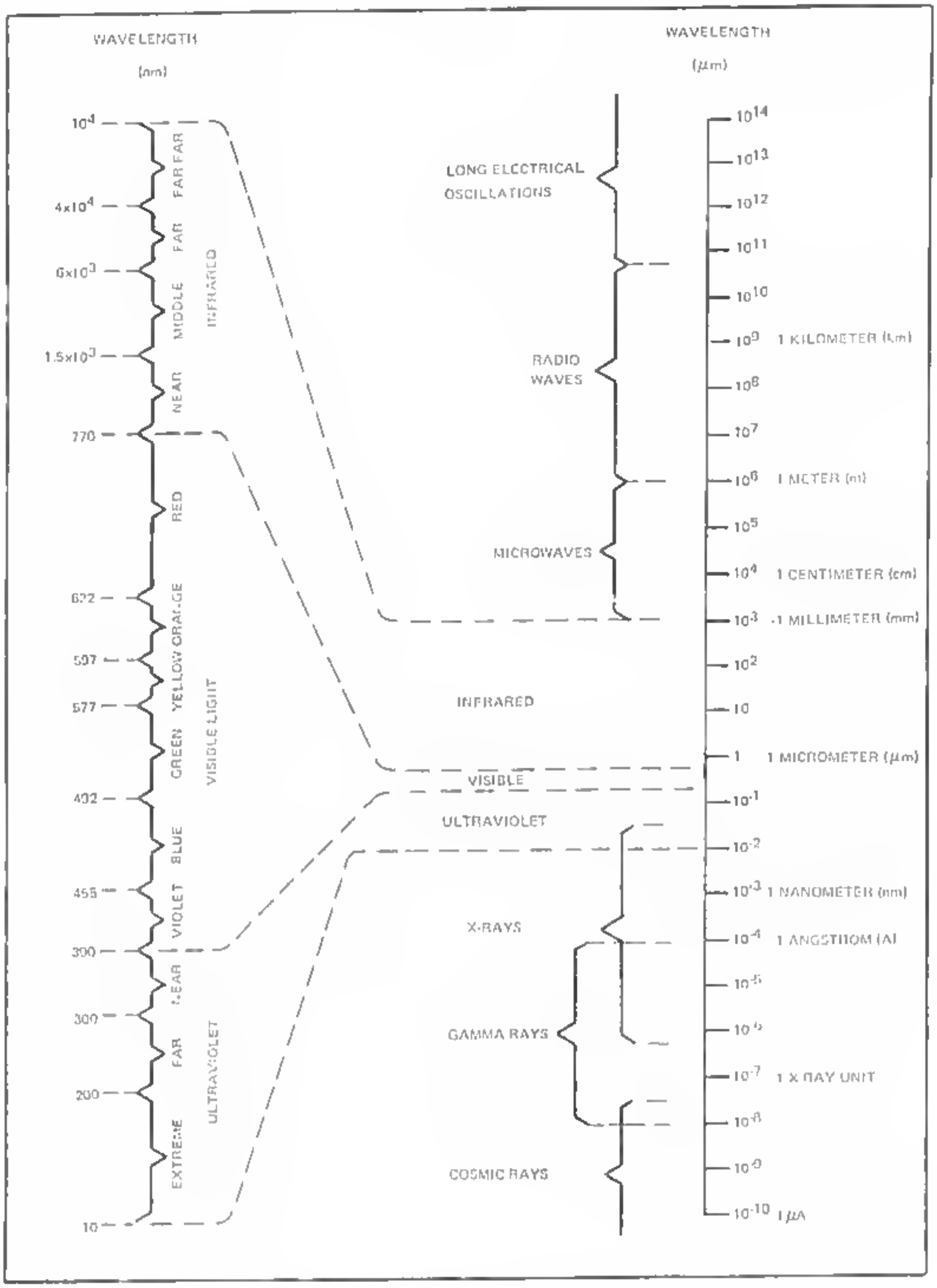


Figure 19-1. The Electromagnetic Spectrum

RADIOMETRIC TERM	SYMBOL	UNITS	PHOTOMETRIC TERM	SYMBOL	COMPARABLE UNITS (ABBREVIATIONS INDICATED IN PARENTHESES)
Radiant Flux	P	Watt	Luminous Flux	F	Lumen (lu)
Radiant Intensity	J	Watt/ω	Luminous Intensity Candlepower	I	1 lu/ω 1 Candle (c)
Irradiance	H	Watt/m^2	Illuminance	E	1 lu/m^2 = 1 lux = 1 Meter-candle (m-c) = 0.0929 ft-candle (ft-c)
Radiance	N	Watt/ω/m^2	Luminance	L	1 lu/ω/m^2 = 1 c/m^3 = 0.3142 Millilambert (mL) = 0.2919 Foot-lambert (ft-L)

Figure 19-2. Radiometric/Photometric Units

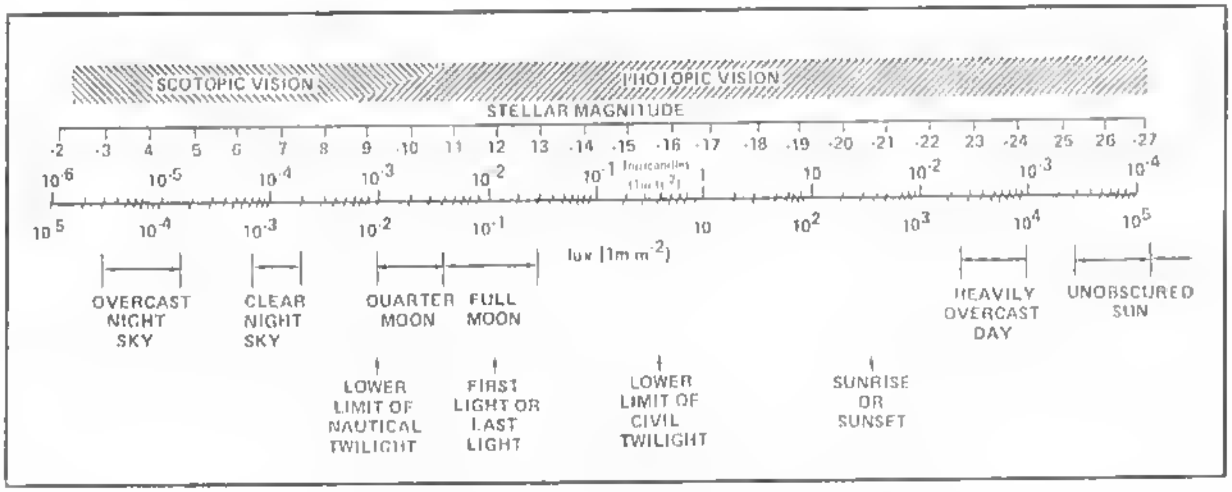


Figure 19-3. Range of Natural Illuminance Levels

reflects toward the Earth only about 7 percent of the sunlight which falls on it. This reflectivity, or the albedo, changes continually as the Moon arcs across the sky. The Moon angle, along its arc, changes approximately 15° per hour (1° every 4 minutes). The ambient light level from the Moon changes as the Moon angle changes. Light from the Moon is brightest when the Moon is at its highest point (zenith). Illuminance at the Earth's surface caused by sunlight reflected from the Moon is affected by the following factors:

1. Phases of the Moon (Figure 19-5) — there are four phases in the lunar cycle. Conditions during each of the four phases of the Moon will conform to a distinct pattern. Half the Moon is always in sunlight, just as half the Earth has day while the other has night. The phases of the Moon depend on how much of the sunlit half can be seen at any one time. In the phase called new Moon, the face is completely in shadow (no apparent disk) and is not visible because its time above the horizon occurs during daylight. The new Moon phase lasts about 8 days, and moonlight increases toward the end of the phase when about half the Moon is illuminated. A relatively low light level is characteristic of this phase and the best time for conducting NVG flight

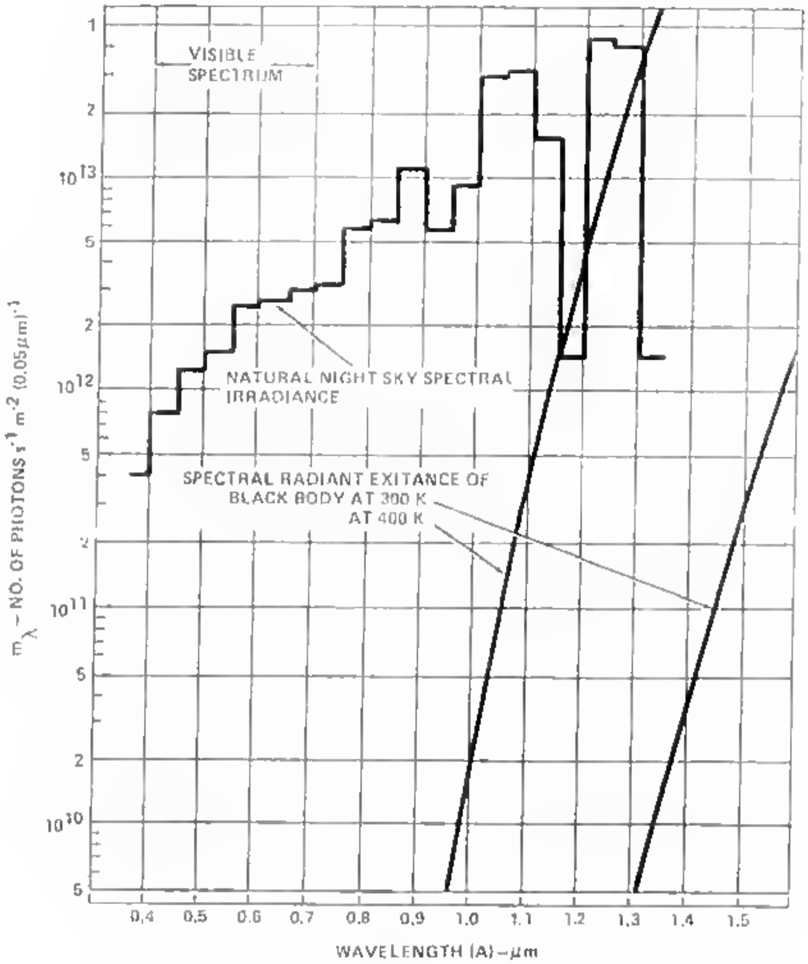


Figure 19-4. Human Eye Response Compared to the Night Sky Spectral Irradiance

operations is at the end of evening nautical twilight (ENT) when skyglow provides operable illuminance. Following the new Moon is the first quarter Moon, usually lasting about 7 days. The first quarter Moon resembles a luminous half circle. Moon illumination at the beginning of the phase is approximately 50 percent. This increases until slightly less than 100 percent of the apparent disk is illuminated. The best time for conducting NVG flight operations is normally just after ENT. The full Moon phase begins when 100 percent of the visible Moon is illuminated, and ends 7 days later when about 50 percent is visible. The best time for conducting NVG flight operations will usually be shortly after midnight. The third quarter Moon is the last phase and lasts about 7 days. It begins when approximately 50 percent of the Moon is visible and ends when 2 percent or less is visible. The best time for conducting NVG flight operations is usually just before the beginning of morning nautical twilight (BMNT). The entire cycle is repeated each lunar month, usually 29 and one-half days.

2. Variation in Earth-Moon distance — during the lunar cycle, there is a total variation of about 26 percent in the distance between the two spheres. As the distance between the Earth and Moon varies, so does the amplitude of illuminance.

3. Difference in albedo on the Moon's surface — differences in reflectance (albedo) of the various illuminated portions of the Moon's surface during

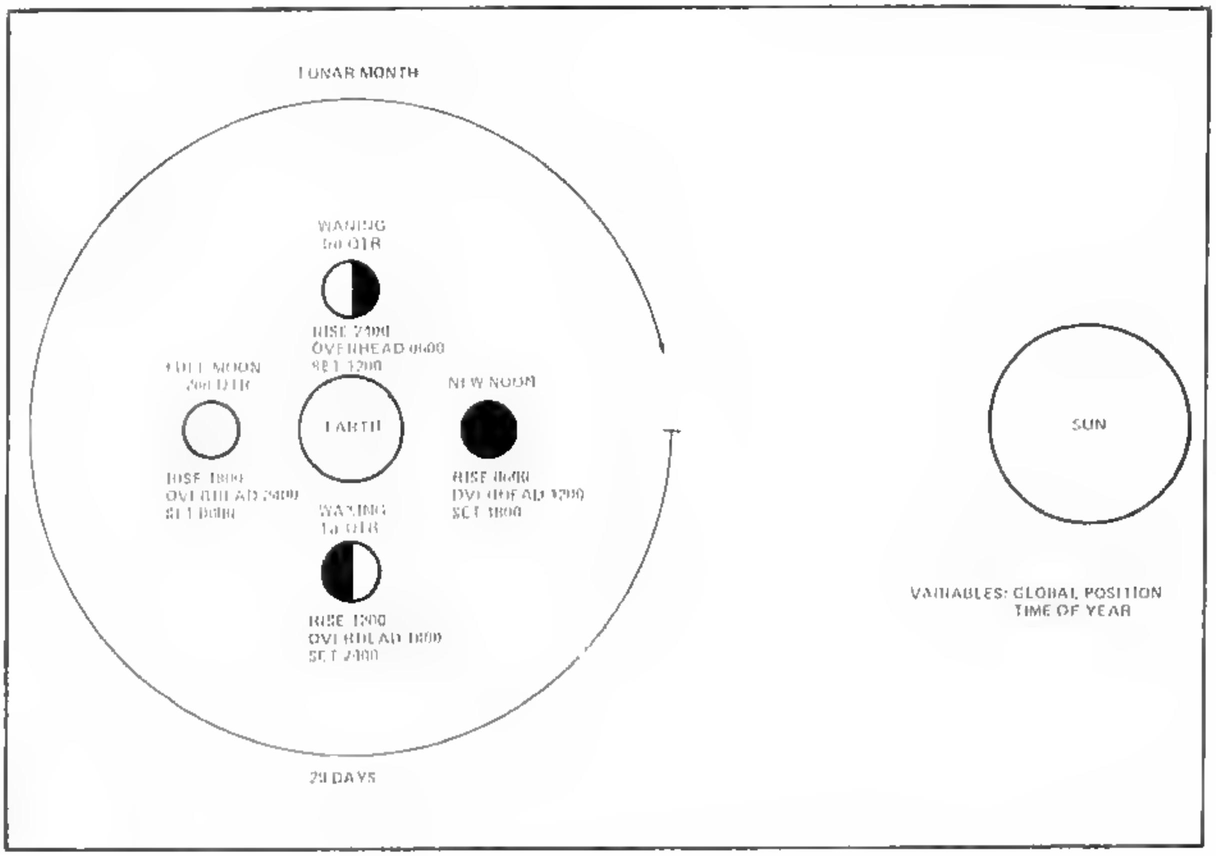


Figure 19-5. Phases of the Moon

the lunar cycle also affect the amount of illumination that reaches the Earth. The Moon is about 20 percent brighter at first quarter (waxing) than at third (waning) because of the difference in the lunar surface.

4. Altitude angle of the Moon — as previously mentioned, the altitude angle of the Moon above the Earth's horizon significantly affects the level of ambient light received. The degree of that effect is graphically portrayed in Figure 19-6.

19.4.2.2 Stars. Of the 8,000 stars visible to the naked eye from Earth only about 2,000 are visible on any given night from either hemisphere. The stars provide an illuminance equivalent to about one-quarter of the actual light from the night sky with no moon. In photometric units, the stars provide approximately 0.00022 lux ground illuminance on a clear night. The majority of stars peak in spectral irradiance between 0.8 and 1.0 micron. This means the majority of optical energy is invisible to the human eye but falls within the response curve of night vision goggles. Starlight has added significance with the introduction of third-generation image intensifier tubes, which have the capability to operate without moonlight.

19.4.2.3 Solar Light. For NVG operations, ambient light from the Sun is usable at certain times following sunset and before sunrise. After sunset, the amount of available solar light steadily decreases until the level of light is not usable. This occurs when the Sun is 12° below the horizon (ENT). Before sunrise, solar light becomes usable when the rising Sun is 12° below the horizon (BMNT). In photometric units, when the Sun is 12° below the horizon, the illuminance level on the Earth's surface is roughly 0.0083 lux. Illuminance levels for various natural sky conditions are shown in Figure 19-7.

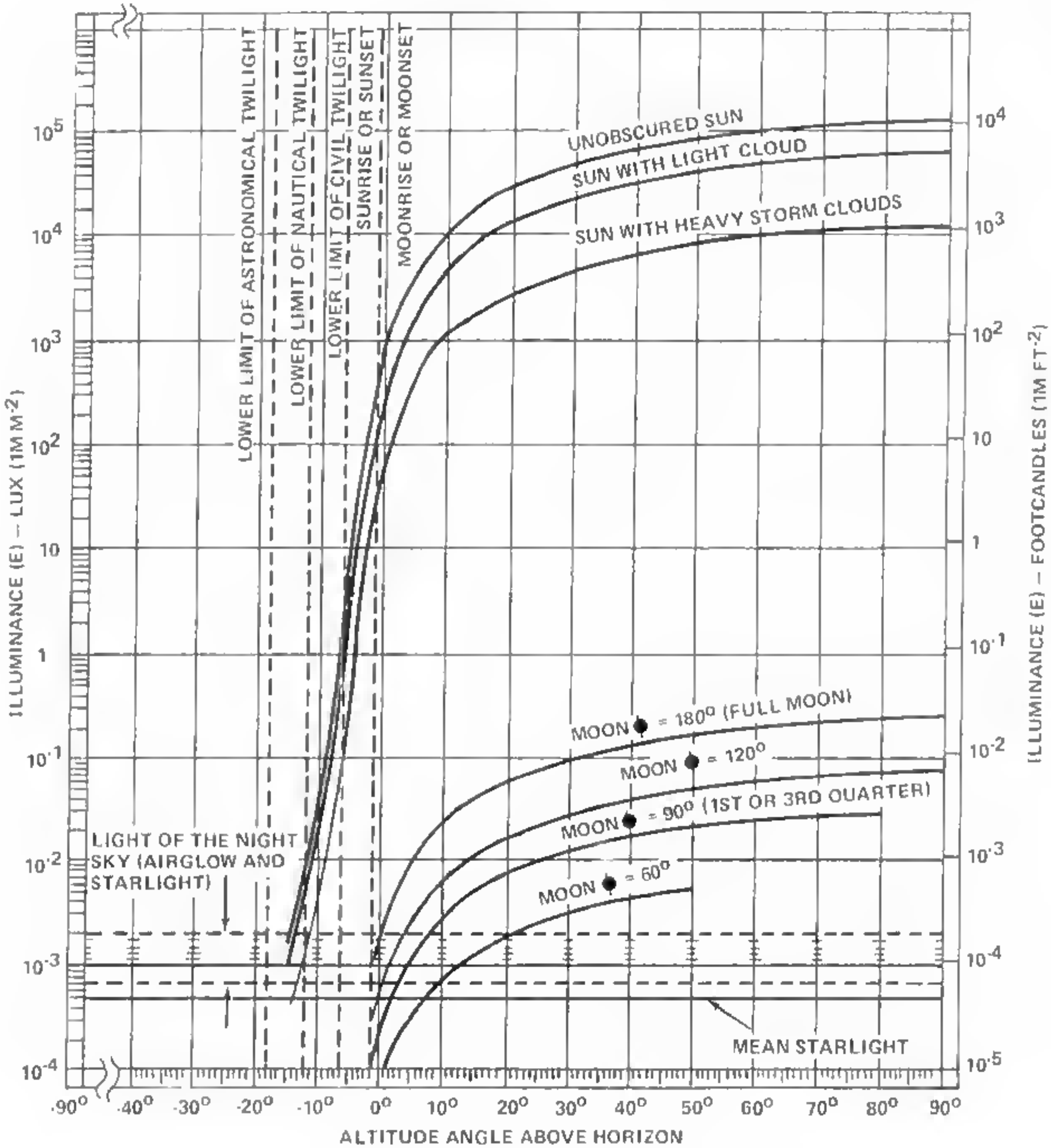


Figure 19-6. Illuminance of the Moon by Altitude Angle and Phase

19.4.2.4 Other Background Illumination. As mentioned earlier, on a moonless night the stars provide about 25 percent of the night sky illumination. However, the greater portion (approximately 40 percent) of the natural light of the night sky, the airglow that originates in the upper atmosphere, is produced by the emission from atoms and molecules. Other minor sources of night illumination are the aurora and zodiacal light caused by

SKY CONDITION	APPROX. LEVELS OF ILLUMINANCE – LUX ($LM\ M^{-2}$)
DIRECT SUNLIGHT	$1\text{-}1.3 \times 10^5$
FULL DAYLIGHT (NOT DIRECT SUNLIGHT)	$1\text{-}2 \times 10^4$
OVERCAST DAY	10^3
VERY DARK DAY	10^2
TWILIGHT	10
DEEP TWILIGHT	1
FULL MOON	10^{-1}
QUARTER MOON	10^{-2}
MOONLESS, CLEAR NIGHT SKY	10^{-3}
MOONLESS, OVERCAST NIGHT SKY	10^{-4}

Figure 19-7. Illuminance Levels of Various Sky Conditions

the scattering of sunlight from interplanetary particulate matter.

19.4.2.5 Artificial Sources. Lights from cities, automobiles, and fires are normally sources of small amounts of illumination. Light from weapon flashes, flares, and explosions contain significant levels of near infrared light and are intensified by NVGs. The light from these sources is most pronounced when overcast conditions exist.

Particular attention has been focused on infrared (IR) searchlights as an artificial source of illumination which is useful in supplying supplemental illumination. It should be remembered that the NVG intensifier tubes will only use infrared light reflected from the terrain, just as they use reflected moonlight. Therefore, infrared searchlights may not be effective in locations where there is a lack of terrain contour, texture, or obstacles. Flat terrain with sparse vegetation offers very little to reflect the infrared light.

19.4.3 Weather and Visibility Restrictions. Thus far, the discussion has centered on illumination from the night sky or artificial sources that help in lighting the terrain for night flight. Weather and other visibility restrictions listed in Figure 19-8 all serve to reduce either the illumination, luminance, or both. This reduction in turn reduces our ability to see key terrain features necessary for flight. An understanding of these limiting conditions is important before progressing to terrain luminance.

ATMOSPHERIC TRANSMISSION WEATHER: CLOUDS, FOG, RAIN, SNOW OBSCURANTS: DUST (BROWN-OUT), SNOW (WHITE-OUT), CHEMICALS
TERRAIN CONTRAST: ALBEDO, TEXTURE SHADOWS: MOON ANGLE
AIRCRAFT HEADING, ALTITUDE, ATTITUDE COCKPIT LIGHTING COCKPIT STRUCTURES

Figure 19-8. Factors Affecting Luminance Used by NVG

Any condition of the atmosphere that absorbs, scatters, or refracts the night sky's illumination, either before or after it strikes the terrain, will effectively reduce the usable light available for the NVGs. The exact amount of reduction is difficult to predict because a common factor cannot be applied to each condition of cloud or fog coverage. An estimation of light reduction can be made by considering the basic illumination as a starting point and then knowing the particle size of the atmospheric condition (i.e., clouds

or fog) and its density (lack of space between particles). Knowing the particle size and the density of the coverage is critical in considering the near infrared wavelengths that must pass through to strike the terrain and be reflected for goggle usage.

19.4.3.1 Clouds. Clouds are very difficult to describe for purposes of calculating their attenuating effects because of their variability. The problem is exacerbated by the fact that water in low level clouds is found in the gaseous, liquid, and sometimes even solid state. For all practical purposes water vapors exist at all temperatures with a relative humidity of 100 percent. Because the amount of water vapor available for any drop formation increases with temperature, summer clouds generally have higher liquid water contents than winter clouds. These liquid water particles are normally all less than 50 micrometers in size, and in general are opaque to visible and near infrared light. This means that thick, dense clouds can be easily seen with NVGs, especially when silhouetted against the night sky. This also means that thick clouds will reduce the amount of illumination that strikes the ground, and therefore will reduce the luminance the NVGs have available for use. Thin and wispy clouds, however, have much more space between their particles, and pass more of the near infrared wavelengths through without being scattered. Because the near infrared wavelength is slightly longer, it has a greater chance of passing through the clouds than does the shorter visible wavelength. It is possible, therefore, for thin and wispy clouds that may be seen with the naked eye (because the visible light is scattered) to be invisible when viewed through the NVGs (because a high proportion of the near infrared light is passing through to the terrain). This potential invisibility is possible given three conditions: 1) the clouds are thin and wispy (or are at least so on the edges of the cloud prior to becoming more dense), 2) the clouds are low level, and set in against the terrain, vice being silhouetted against the night sky, and 3) the ambient illumination is either very high (causing de-gain of the intensifier tubes) or very low (causing graininess).

The invisibility of thin clouds that progress to thicker ones hiding terrain features can create a severe hazard for NVG operations. In that regard, a common question occurs: "If the cloud is invisible, why can't a pilot see the terrain behind it?" The answer is predictably complex. First, the cloud reduces visual and near infrared contrasts and detail. This produces a false perception of distance, resulting in a pilot either not seeing the terrain, or thinking it is much farther away than it actually is. Second, the cloud may get progressively thicker, allowing the pilot to progress through the cloud without initially perceiving a cloud wall. If a cloud is perceived, it is (once again) thought to be off at a distance.

19.4.3.2 Fog. Fog is another atmospheric condition of concern for the NVG operator. Its effect on NVGs, however, is similar to that of clouds. Generally, fog is distinguished from clouds only in regard to its distance from the ground.

Particle size varies between 2 and 20 micrometers, very similar to that of clouds. Typically, fog has fewer particles, and a smaller range of particle size than clouds. Fog is most likely seasonal, and early morning the most likely time to encounter fog. Urban areas tend to have less fog (probably because of urban heat islands) than rural areas, and mountainous areas tend to have more fog than sites nearer sea level.

19.4.3.3 Rain. Rain, like clouds, is difficult to predict in regard to its effect on NVGs. Droplet size and density are key ingredients to visibility or invisibility through the device. Light rains or mists cannot be seen by the NVG, but will affect contrast, distance, estimation, and depth perception. Heavy rains are more easily perceived due to the large droplet light attenuation and droplet formation on the windscreen.

19.4.3.4 Snow. Snow occurs in a wide range of particle sizes and geometries. Snow crystals, while small in size, are generally large in comparison to the wavelength of visible and near infrared light, and will easily block or scatter those wavelengths. However, snow will not normally degrade infrared light as much as fog and rain, because of its lesser density. The greatest density condition involving snow will occur during a helicopter landing or hover, when rotor wash creates the familiar *white-out* reflection. Terrain recognition is more difficult in a snowy region, because of a combination of a reduction in contrast and increase in reflectivity.

19.4.3.5 Sand/Dust. The effect of blowing sand and or dust is similar to that created by snow, except that the particulates are far less reflective and much larger. The effect on the intensifier tube in this condition is significant in that it completely blocks the near infrared light striking and reflecting from the terrain. This brown-out condition is especially common during desert landings.

19.4.3.6 Obscurants. Battlefield obscurants, whether smoke or chemical, produce similar effects to those described above. They will be most effective if they contain a mixture of small and large particulates, and are fairly dense. Attenuation by either absorption, reflection, or a combination of both, may be used as a countermeasure against NVG operations.

The atmospheric conditions described on the previous pages all reduce the ambient illumination level. Recognition of this reduction in the cockpit is sometimes very difficult. The changes are often very subtle reductions in contrast, which are not perceived when viewed through the NVGs. Pilots should keep in mind that the image intensifier tubes have a feature called automatic gain control which, in effect, hides these subtle changes by attempting to provide a constant image in spite of changing luminance conditions. If cues are perceivable, the pilot will have to be looking for them to catch their significance. Common cues to reductions in ambient illumination due to visibility restrictions include loss of celestial lights, loss of ground lights, reduced contrast, reduced depth perception/distance estimation, reduced acuity or resolution, increased graininess or video noise, and an increased *halo* effect around light sources.

19.4.4 Terrain Luminance. Our ability to see key terrain features is solely a function of the amount of light reflected off those features. Illumination from the night sky or some artificial source reflects off the terrain in varying degrees (albedo) thereby allowing us to see that terrain. Reflection in the visible spectrum is used by the naked eye while reflections of near infrared wavelengths are used by NVG intensifier tubes. Two characteristics of the illuminated terrain are responsible for our ability or inability to distinguish differences in terrain features.

19.4.4.1 Contrast. Contrast is a measure of the luminance difference between two or more surfaces. Contrast can vary from 100 percent (negative) to 0 for surfaces darker than their backgrounds, and from 0 to infinity (positive) for surfaces brighter than their backgrounds. Contrast in the night terrain environment is dependent upon differing albedo values for each type of terrain surface. Albedo is again the ratio of incidence to reflected light. Since the eyes and the night vision goggles use reflected light off the terrain, albedos are critical in determining the amount of light available for night terrain avoidance. Figure 19-9 lists some albedo values for various types of terrain surfaces. These differences can become very important especially at lower ambient light levels. As an example, a flight progressing from fields covered with fresh snow (0.85 albedo) to a stand of coniferous trees (0.14 albedo) on a clear moonless night (0.0008 lux) creates very different levels of terrain luminance. Over the snow 85 percent of the incident light is reflected off the terrain while the coniferous trees reflect only 14 percent of the same incident light. The effect of albedo contrast is more pronounced at lower ambient light levels.

Although differences in reflectivity can be seen with the naked eye, these differences would only relate to the reflectance characteristics of the visible spectrum. In order to get a true picture of reflectance in near infrared wavelengths used by the NVG, specific albedos must be circulated for this portion of the spectrum. Albedos will also vary with conditions of the terrain even though terrain type remains constant. For instance, dry sand is twice as reflective as wet sand. Overall contrast is improved with higher light levels. As the ambient light increases, more light is reflected, shades become more recognizable, and an object's overall definition is improved. Objects with a poor reflective surface appear black during low light levels and dark gray during high light levels. Objects or terrain features with good reflective quality appear gray and become progressively lighter as the ambient light increases. The relationship between reflectivity and contrast is shown in Figure 19-10. Some specific examples of the effects of contrast are as follows:

1. Roads — the surface of some dirt roads provides excellent contrast with surrounding terrain. Roads that cut through heavy forested areas are easily recognized if visible through foliage. The light color of concrete highways, normally an excellent reflective surface, is easily identified during most light-level conditions. Asphalt roads, however, are usually difficult to identify because the dark surface absorbs available light; although in desert areas, the surrounding contrast can make them readily detectable.

2. Water — there is very little color contrast between a landmass and a body of water during low light conditions. When viewed from the air, lakes or rivers appear dark gray in color. As the light level increases, water begins to change color, land-water contrast increases, and reflected moonlight is easily detected. When a surface wind exists, the ripples on

SOILS	DRY	WET	WETNESS UNSPECIFIED/INDIFFERENT
DARK	0.13	0.08	
LIGHT	0.18	0.10	
DARK – PLOWED	0.08	0.06	
LIGHT – PLOWED	0.16	0.08	
CLAY	0.23	0.16	
SANDY	0.25	0.18	
SAND	0.40	0.20	
WHITE SAND	0.55		
SURFACES			
ASPHALT			0.10
LAVA			0.10
TUNDRA			0.20
STEPPE			0.20
CONCRETE			0.30
STONE			0.30
DESERT			0.30
ROCK	0.35	0.20	
DIRT ROAD	0.25	0.18	
CLAY ROAD	0.30	0.20	

FIELDS	GROWING	DORMANT	GREENNESS UNSPECIFIED/INDIFFERENT
TALL GRASS	0.18	0.13	0.15
MOWED GRASS	0.25	0.19	0.22
DESIDUOUS TREES	0.18	0.12	0.15
CONIFEROUS TREES	0.14	0.12	0.13
RICE	0.12		
BEST WHEAT	0.18		
POTATO	0.19		
RYE	0.20		
COTTON	0.21		
LETTUCE	0.22		

SNOW	
FRESH	0.85
DENSE	0.75
MOIST	0.65
OLD	0.55
MELTING	0.35

ICE	
WHITE	0.75
GRAY	0.60
SNOW & ICE	0.65
DARK GLASS	0.10

Figure 19-9. Albedos for Various Surfaces

the surface improve the contrast, which further aids in terrain identification.

3. Open fields — contrast is very poor in fields covered with vegetation. Most crops are dark-colored and absorb light. During the harvest or the dormant season, the color of vegetation changes to a lighter color and contrast improves. A freshly plowed field may lack vegetation. Because of the coarse texture of the upturned soil, light is absorbed and very little light is reflected.

4. Forested areas — heavily forested areas do not reflect light and generally appear as dark areas at night. Because heavy vegetation provides no contrast, forests conceal objects and terrain features.

% REFLECTIVE	% CONTRAST
GRASS 25	ASPHALT/GRASS 18
LEAF 23	ASPHALT/SNOW 73
PINE. 36	DIRT/GRASS. 41
SAND 37	GRASS/LEAF 11
SNOW. 78	SAND/LEAF 39

Figure 19-10. Example of Terrain Contrast

Excellent contrast does exist, however, between deciduous and coniferous trees as well as between open fields and surrounding forested areas.

5. Desert — camouflaged military targets are normally hard to recognize in the desert. During high illumination, mountain ranges can be easily identified because of the dark color of barren mountains against the light color of the desert floor. Lower rises in terrain between the viewer and the higher ranges are, however, difficult to identify in low ambient light.

19.4.4.2 Shadows. In the previous example between the snow field and coniferous trees, the snow field clearly had higher reflectivity. It should be noted, however, that our ability to distinguish terrain features is also dependent upon shadows produced by contours creating a luminous texture. The trees obviously have an advantage over a snow-covered field where lack of contrast hides important characteristics of the terrain. Shadows are dependent on the angle of the light source (Moon) and the contour of the terrain. Every object or surface will cast a shadow if there is sufficient contour and a light source. The direction in which the shadow is cast depends on the position of the light source.

19.4.5 Light Prediction and Measurement. Ambient light level prediction and measurement are very complex processes requiring an appreciation for the limitations involved. Illumination prediction using Moon fractionalization and angle is an important planning tool that has recently been approved by the USMC Computer Generated Global Light Level Calendar (revised as Lite Level User's Guide). The program provides global prediction based on latitude/longitude for the next 30 years, with greater accuracy and reliability than previous methods. As useful as this system is for planning purposes, however, the predictions provide only limited information concerning ambient illumination based on Moon phases. As shown in Figure 19-3, many factors affect the amount of light reaching the intensifier tubes of the NVG. The prediction process, while extremely useful for baseline planning, does not provide real time enroute light level data. Variables such as weather, Moon angle, and terrain shadowing, terrain albedos, and aircraft heading can significantly alter the luminance used by the NVG. Light level variations are insidious and their recognition is critical to terrain avoidance.

An example of limitation encountered in attempting to predict usable illumination may prove beneficial here. For a given evening, the light level calendar may predict an illumination value of 0.0093 lux (based on a Moon fractionalization of 84 percent, located 12° above the horizon). NVG flight would be authorized under these conditions in that the levels presented exceed the HQMC minimum light level (0.0022 lux). Flight planning would hopefully take into account the low angle Moon and associated terrain shadowing hazards. But weather would also have to be taken into account. For example, a broken layer at 2,000 feet, regardless of the predicted illumination levels, would reduce the actual illumination striking the terrain to below those levels prescribed by HQMC. In effect,

this flight should be cancelled. This scenario is relatively straightforward, but becomes more complex as soon as en route weather and illumination criteria are introduced. The potential en route changes, for whatever reason (shadows, weather, etc.), have created a perceived need for a portable, in-flight, light level measurement device.

Before adapting any device such as an NVG photometer, four criteria must be met to ensure its adequacy for NVG operations. First, the device must be *convenient* for use; small, lightweight, and without external cords, wires, or power sources. Second, the device must measure luminance, not illumination. Luminance is the ambient light that is reflected up off of the terrain, and is measured in foot-lamberts. In order for the device to measure reflected light, it must possess spotmeter capabilities that restrict light level measurement to a particular field of regard. Third, the device should be sensitive to the same wavelengths as the NVG. Most simple photometers use a silicon sensor which is disproportionately sensitive to visible wavelengths. The NVG photometer should contain a gallium arsenide sensor element which possesses the same wavelength sensitivity as both the PVS-5 and the ANVIS system. Fourth, the device must have a relatively large dynamic range, yet be sensitive enough to provide measurements from full moonlight to cloudy starlight. The gallium arsenide sensor can provide this level of sensitivity.

The operational employment of such a device, given that it meets these four basic criteria, would still be very difficult because of the dynamic nature of the luminance variables throughout the course of a mission. As one variable changes, the overall illumination will change. Because continuous monitoring of light levels is required (within a specific operating area) to keep pace with the dynamic night terrain environment, the application of such a device may never prove practical. Continuous use of a hand-held device would predictably lead to task saturation, with a disproportionate priority of cockpit time spent on light level measurement.

Aside from the global light level calendar, the continued use of weather reports, terrain albedo, NVG experience, low-light level cues (graining, voltage gain), comfort level, and sound judgment should guide our decisions in determining mission go/no-go status.

APPENDIX A

External Stores Limitations

A.1. INTRODUCTION

The OV-10 aircraft can use a wide range of conventional weapons suspended from a maximum of five stations beneath the fuselage and sponsons and two stations beneath the wing. All authorized stores and their limitations are listed in Figure A-1. Weight and drag data are contained in Figures A-2 and A-3.

A.2. CHANGE REQUESTS

1. Authorization for carriage and/or release of additional store loadings or new stores must be obtained by message or letter from the Naval Air Systems Command. Message request should be transmitted as follows:

FM: REQUESTING ACTIVITY//CODE//
TO: TYPE COMMANDER//CODE//
INFO: COMNAVAIRSYSCOMWASHINGTON DC//530B/540//
NAVAIRTESTCEN PATUXENT RIVER MD//SA80//
MAWTS ONE//

UNCLAS //N13034// (CLASSIFY REQUESTS AS APPROPRIATE)
SUBJ:OV-10A/D TACTICAL MANUAL STORES LIMITATION CHANGE RECOMMENDATION
MESGID//GENADMIN/ORIGINATOR CODE//
REF/A/DOC/NWP 55-6-OV10A/D//
(If only one ref) AMAN/REF A IS AN AIRCRAFT TACTICAL MANUAL//
(If more than one ref)NARR/(ect.)

RMKS/1. State request, giving reason and justification for change.

2. Letter requests, with copies to the above information addressees, should be addressed as follows:

Commander, Naval Air Systems Command
(AIR-530B)
Naval Air Systems Command Headquarters
Washington, DC 20361-5300

3. Additional assistance may be obtained from the following sources:

Naval Air Systems Command
(AIR-530B)
Flight Clearance Officer
DSN: 222-3547
COMMERCIAL: 703-692-3547

NAVAIRTESTCEN (SA81) Patuxent River, MD 20670-5304
DSN 326-4171, Comm. 301-863-4171

MAWTS-1
OV-10 BRANCH
DSN: 951-2904
Commercial: 602-726-2952

A.3. STORES LOADINGS

1. Figure A-1 depicts stores stations and lists limitations for carriage, employment, and jettison. Specific notes referenced in the Remarks column of Figure A-1 are located on sheet 6 of the figure. Figures A-2 and A-3 list authorized stores with approximate weights.

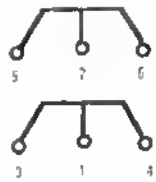
2. Only the configurations shown in the stores limitation tables and configurations properly derived from those shown may be carried, employed, or jettisoned. Unauthorized loads may result in overstress or unpredictable separation characteristics.

3. Mixed loads are authorized subject to the following restrictions:

(a) Carriage limitations are those of the most restrictive store carried; release and jettison limitations for the individual store apply.

(b) Stores may be carried only on stations for which they are specifically authorized in Figure A-1.

4. PMBR stations are identified as shown below:



A.4. OEFINITIONS

The following terms used in this section are defined below:

LBA - Limits of the basic aircraft without external stores

NA - Not authorized.

A.5. GENERAL RESTRICTIONS

1. The following restrictions apply to carriage and employment of the configurations shown in the stores limitations tables and to their derivable configurations.

2. The stores listed in the tables may be carried or employed, singly or in combination, to the limits shown. The limits of the most restricted store apply.

3. All of the configurations shown in the stores limitation tables may be carried.

4. For normal aircraft operation limitations and maneuvers, refer to the NATOPS Flight Manual.

5. Unless otherwise noted, balanced flight shall be maintained during store employment.

A.6. DERIVABLE CONFIGURATIONS

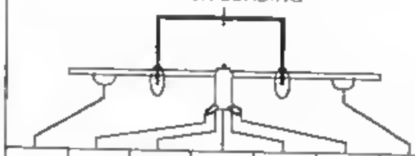
1. For additional flexibility, ground rules have been established to authorize derivable configurations (downloading) of any specific configuration shown in the tables. The ground rules in the following paragraphs for downloading and substitution MUST BE followed.

2. All derivable configurations shall comply with aircraft asymmetry and weight limits for takeoff, flight, or landing.

3. Configurations may be downloaded in any station sequence unless noted otherwise in the remarks column of Figure A-1.

A.7. JETTISON RESTRICTIONS

Unless otherwise noted in the tables, select or emergency jettison for all stores shall be in unaccelerated 1.0 g level flight.



BOMBS, PRACTICE BOMBS	LOAD NUMBER	STATION LOADING L	1	2	3	4	5	R	MAXIMUM AIRSPEED (KIAS) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	ACCELERATION (G) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	MAX DIVE ANGLE (DEGREES)	RELEASE INTERVAL (MODE)	REMARKS
BOMB MK 81 WITH MAU 94 CONICAL MK 14 LOW DRAG MK 14 HIGH DRAG	1		●	●	●	●	●		350	300	300	LBA	-0.7 TO +1.0	[illegible] LEVEL	45	SINGLE OR DUAL	
BOMB, MK 82/BDU-45/B WITH MAU 93 OR BSU 33 CONICAL MK 15 LOW DRAG MK 15 HIGH DRAG	2		●	●	●	●	●		350	350	350	0.0 TO +6.0	-0.7 TO +1.0	[illegible] LEVEL	45	SINGLE OR DUAL	
BOMB MK 83 CONICAL	3				●				350	350	350	0.0 TO +6.0	-0.7 TO +1.0	[illegible] LEVEL	45	SINGLE	
PRACTICE BOMBS MK 76 BDU 33 D/B MK 106 MOD 5 BDU 48/B	4		●		●		●		350	325	150 WITH PMBR	0.0 TO +5.0	-0.7 TO [illegible]	+1.0 LEVEL WITH PMBR	45	NO LIMIT	SEE TEXT SEE NOTE [illegible]
	5			●		●			350	325	150 WITH PMBR	0.0 TO +5.0	[illegible] TO [illegible]	+1.0 LEVEL WITH PMBR	45	NO LIMIT	SEE TEXT SEE NOTE [illegible]
	6	●						●	350	325	150 WITH PMBR	0.0 TO +4.5	-0.7 TO [illegible]	[illegible] LEVEL WITH PMBR	45	NO LIMIT	WING PYLONS [illegible] FOR OV-10D ONLY SEE NOTE [illegible]
	7																

Figure A-1. External Stores Limitations (Sheet 1 of 6)

ROCKETS, MISSILES	LOAD NUMBER	STATION LOADING L	1	2	3	4	5	R	MAXIMUM AIRSPEED (KIAS) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	ACCELERATION (G) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	MAX DIVE ANGLE (DEGREES)	RELEASE INTERVAL (MODE)	REMARKS
ROCKET LAUNCHERS 2.75 IN LAU-61A/A, B/A, D/A LAU-68B/A, D/A	8		●	●		●	●		350	325	150	0.0 TO +5.0	-0.7 TO +4.0	+1.0 LEVEL	45	SINGLE RIPPLE	NO AIRCRAFT STATION LIMIT SEE NOTE 5, 6
ROCKET LAUNCHERS 2.75 IN LAU-68B/A, D/A	9	●						●	350	200 MIN 350 MAX RIPPL	150 EMPTY 200 FULL	0.0 TO +4.5	-0.7 TO +1.0	+1.0 LEVEL	45		WING PYLONS (L & R) FOR OV-10D ONLY SEE NOTE 5, 6
ROCKET LAUNCHERS 5.0 INCH LAU-10C/A, D/A	10		●	●		●	●		350	325	150	0.0 TO +5.0	-0.7 TO +4.0	+1.0 LEVEL	45	SINGLE RIPPLE	NO AIRCRAFT STATION LIMIT SEE NOTE 4, 6
	11	●						●	350	200 MIN 350 MAX	150 EMPTY 200 FULL	0.0 TO +4.5	-0.7 TO +1.0	+1.0 LEVEL	45		OV-10D ONLY SEE NOTE 4, 5
MISSILE AIM-9H/L/M	12	●						●	LBA	LBA	NA	LBA	+1.0 TO +1.5	NA			OV-10A AND OV-10D WITH AFC-90 INCORP. ADU-299 AND LAU-7 REQUIRED FOR CARRIAGE SEE NOTE 10
	13																

Figure A-1. External Stores Limitations (Sheet 2 of 6)

FIRE BOMB FAE	LOAD NUMBER	STATION LOADING L	1	2	3	4	5	R	MAXIMUM AIRSPEED (KIAS) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	ACCELERATION (G) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	MAX DIVE ANGLE (DEGREES)	RELEASE INTERVAL (MODE)	REMARKS
FIRE BOMB MK 77 MOD 4 5	14		●		●		●		300	200	200	0.0 TO +4.0	+1.0 TO +2.0	+1.0 LEVEL	5	SINGLE	MK 13 INITIATOR NOT AUTHORIZED SEE NOTE 12
	15			●		●			300	200	200	0.0 TO +4.0	+1.0 TO +2.0	+1.0 LEVEL	5	SINGLE	MK 13 INITIATOR NOT AUTHORIZED SEE NOTE 12
FAE CBU-55B A B	16		●		●		●		350	300	300	0.0 TO +5.0	0.5 TO +4.0	+1.0 LEVEL	60	SINGLE	
	17			●		●			350	300	300	0.0 TO +5.0	0.5 TO +4.0	+1.0 LEVEL	60	SINGLE	
	18		●	●	●	●	●		350	150 TO 250	150 TO 250	-0.5 TO +3.0	SEE NOTE	+1.0 LEVEL	SEE NOTE	SINGLE	WITH 5 CBU'S AIRCRAFT STATIONS 1 3 & 5 MUST BE RELEASED PRIOR TO STATIONS 2 & 4 SEE NOTE 8
	19																

Figure A-1. External Stores Limitations (Sheet 3 of 6)

FUEL TANKS PODS	LOAD NUMBER	STATION LOADING L	1	2	3	4	5	R	MAXIMUM AIRSPEED (KIAS) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	ACCELERATION (G) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	MAX DIVE ANGLE (DEGREES)	RELEASE INTERVAL (MODE)	REMARKS
FPU-3/A 150 GAL	20				●				350		150	0.0 TO +5.5		+1.0 LEVEL			SEE NOTES 1, 13
230 GAL (USAF)	21				●				350		150	0.0 TO +5.5 SYM 0.0 TO +4.5 UNSYM		+1.0 LEVEL			ROUGH FIELD OPERATIONS NOT AUTHORIZED SEE NOTE 1
AERO-1D, 300 GAL	22				●				175		120 OR 85	0.0 TO 2.0		+1.0 LEVEL			ROUGH FIELD OPERATIONS NOT AUTHORIZED SEE NOTES 2, 3
P/N 8478-16100 100 GAL	23	●						●	350		150	1.0 TO +4.5		+1.0 LEVEL			OV-10D ONLY
TACTS POD P-3/P-4	24	●						●	LBA	NA	NA	LBA	NA	NA			OV-10A AND OV-10D WITH AFC 90 INCORP ADU 299 AND LAU 7 REQUIRED FOR CARRIAGE
GUN POD GPU-2A	25			●		●			350	350	250	0.0 TO +4.5	-0.5 TO +4.0	+1.0 LEVEL	60	NO LIMIT	DO NOT LOAD ADJACENT STATIONS. ONLY LOW RATE OF FIRE AUTHORIZED FOR PODS WITHOUT AAC 716 SEE NOTE 9

Figure A-1. External Stores Limitations (Sheet 4 of 6)

FLARES, SEISMIC SENSORS	LOAD NUMBER	STATION LOADING L	1	2	3	4	5	R	MAXIMUM AIRSPEED (KIAS) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	ACCELERATION (G) CARRIAGE	LAUNCH/FIRE RELEASE	JETTISON	MAX DIVE ANGLE (DEGREES)	RELEASE INTERVAL (MODE)	REMARKS
FLARES AND DISPENSERS, SUU 25 F A LUU-2A B B B OR SUU 44 A LUU 2A B B B MK 45	26		●	●	●	●	●		350	250	200	0.0 TO +6.0	+1.0	+1.0 LEVEL	10	NO LIMIT	
	27	●						●	350	150 MIN 350 MAX	150	0.0 TO 4.5	+1.0	+1.0 LEVEL	10	NO LIMIT	OV 10D ONLY
AN ALE-39 CHAFF FLARE DISPENSER	28			INTERNAL CARRIAGE					LBA	LBA	LBA	LBA	LBA	LBA	LBA		
SEISMIC SENSOR ADSID III(S) WITH PMBR	29								350	250	150 WITH PMBR	0.0 TO +5.5	+1.0 LEVEL	+1.0 LEVEL WITH PMBR	0	NO LIMIT	WING PYLONS (L & R) FOR OV 10D ONLY
SEISMIC SENSOR ADSID III(N) WITH PMBR	30								350	250	150 WITH PMBR	0.0 TO +5.5	+1.0 LEVEL	+1.0 LEVEL WITH PMBR	0	NO LIMIT	WING PYLONS (L & R) FOR OV 10D ONLY. LOAD ADSID III(N) ON PMBR STATIONS 2, 3, & 4 ONLY
	31								350	250	150 WITH PMBR	0.0 TO +5.5	+1.0 LEVEL	+1.0 LEVEL WITH PMBR	0	NO LIMIT	
	32																

Figure A-1. External Stores Limitations (Sheet 5 of 6)

NOTES	
1.	INSTALLATION AND CARRIAGE OF AERO-1C, FPU-3/A OR USAF 230 GALLON EXTERNAL FUEL TANK REQUIRES THE AERO-1A ADAPTER WITH AERO-65A RACK.
2.	JETTISON IN EMERGENCY ONLY 120 KIAS, 1.0 G LEVEL FLIGHT, GEAR UP, FLAPS UP OR 85 KIAS, 1.0G LEVEL FLIGHT, GEAR DOWN, FLAPS FULL DOWN. AERO-1D FUEL TANK REQUIRES THE USE OF ADAPTER P/N 601D23031 TO PROVIDE ADEQUATE SWAY BRACING. LONG TAIL CONE WITH TWO HORIZONTAL FINS IS THE ONLY AUTHORIZED FIN CONFIGURATION.
3.	WHEN CARRYING AERO-1D ON STATION 3, STATIONS 1, 2, 4 AND 5 SHALL BE EMPTY. WING STATIONS MAY BE LOADED WITH AUTHORIZED STORES.
4.	INCREASED SPONSON LEADING EDGE EROSION CAN BE EXPECTED WHEN FIRING 5 IN. ROCKETS WITH MK 71 MOD 1 MOTORS.
5.	INITIATE PULL UP IMMEDIATELY AFTER FIRING 2.75 IN. ROCKET.
6.	RIPPLE FIRING IS ALLOWED FOR UP TO FOUR AIRCRAFT STATIONS WITH LAU-61 OR LAU-68 SERIES. RIPPLE FIRING IS LIMITED TO A SINGLE AIRCRAFT STATION FOR LAU-10 SERIES. TAIL FAIRINGS SHOULD BE INSTALLED ON ALL ROCKET LAUNCHERS.
7.	WHEN CARRYING 4 OR MORE CBU-55'S, ONE OR MORE FINS MUST BE FOLDED TO PREVENT PHYSICAL INTERFERENCE. FIN(S) TO BE FOLDED IS (ARE) DESIGNATED AS UPPER OR LOWER, LEFT OR RIGHT AS SEEN LOOKING AT THE TAIL OF THE STORE.
8.	FOR SHORT-FIELD OR ROUGH-FIELD LANDINGS, A MAXIMUM OF THREE CBU'S CAN BE CARRIED (ONE EACH SIDE AND CENTER LINE).
9.	WHEN EMPLOYING GPU-2/A FROM AERO-65 BOMB RACKS, THE LINEAR ELECTRO-MECHANICAL ACTUATOR (LEMA) MUST BE REMOVED PER PROCEDURES OF NAVAIR 11-5E-50. THE SECONDARY RELEASE MECHANISM WILL BE INSPECTED PER NAVAIR 01-60GCB-75. JETTISON HANDLE MUST BE USED TO JETTISON. LEMA MUST BE REINSTALLED PRIOR TO NON-GPU-2/A MISSIONS.
10.	WHEN EMPLOYING AIM-9 FROM AERO-65 BOMB RACKS ON OV-10D, THE LEMA MUST BE REMOVED PER PROCEDURES OF NAVAIR 11-5E-50. LEMA MUST BE REINSTALLED PRIOR TO NON-AIM-9 MISSIONS.
11.	WHEN CARRYING THE A/A37B-3 PMBR, ADJACENT SPONSON STATIONS SHALL NOT BE LOADED.
12.	WHEN CARRYING THE MK 77 FIRE BOMB, STORES ON ADJACENT SPONSON STATIONS ARE LIMITED TO A DIAMETER NOT EXCEEDING 14 INCHES.
13.	WHEN CARRYING THE AERO-1C OR FPU-3/A FUEL TANK, STORES ON SPONSON STATIONS 2 AND 4 ARE LIMITED TO A DIAMETER NOT EXCEEDING 12 INCHES.

Figure A-1. External Stores Limitations (Sheet 6 of 6)

OV-10A

BASIC AIRCRAFT (SPONSONS, SPONSON GUNS ℄ PYLON) DRAG - ZERO

NOTE IN CASE OF MIXED STORES USE HIGHEST DRAG INDEX

ITEM	STATION L	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION R	WEIGHT-LBS FULL	WEIGHT-LBS EMPTY	DRAG NUMBER SINGLE	DRAG NUMBER ADJACENT	DRAG NUMBER MULTIPLE
AIRCRAFT OPERATING WEIGHT INCLUDES									8543			
SPONSONS (TWO) WITH RACKS								272		21.0		
M60C GUNS (FOUR) COMPLETE								150				
AMMUNITION 2000 ROUNDS								130				
CENTERLINE PYLON				X				52		1.5		
AERO-1C OR FPU-3 A (JP-5)				X				1155	135	14.0		24.0
AERO-1D (JP-5)				X				2229	189	14.0		
230 GALLON TANK (JP-5)				X				1774	246	12.0		21.0
GENERAL PURPOSE BOMBS												
MK 81 WITH MAU-93 CONICAL FINS		X	X	X	X	X		260		4.0	5.0	6.0
MK 81 WITH MK 14 LOW HIGH DRAG FIN		X	X	X	X	X		305		6.5	7.5	8.0
MK 82 BDU-45/B WITH MAU-93 BSU 33 CONICAL FIN		X	X	X	X	X		531		5.0	6.0	7.0
MK 82 BDU-45/B WITH MK 15 LOW-HIGH DRAG FIN		X	X	X	X	X		565		9.0	10.0	11.0
MK 83 CONICAL FIN				X				985		9.0	10.5	12.0
FIRE BOMBS												
MK 77 MOD 4-5		X	X	X	X	X		520		8.0	10.0	12.0
CLUSTER BOMBS												
CBU 55 B (FAE) OR CBU 55A B (FAE)		X	X	X	X	X		519		13.0	20.0	27.0
PRACTICE BOMBS												
A A37B-3 (PMBR)									87.0	10.0	12.0	14.0
SIX MK 76, BDU-33 D B		X	X	X	X	X		237	87.0	18.5	25.0	32.0
SIX MK 106, BDU-48/B		X	X	X	X	X		147	87.0	25.0	34.0	45.0
MISSILES												
AIM 9 (WITH LAU 7)												
FULL	X						X	282		15.0		
FIRED									87.0	5.0		
TACTS (WITH LAU-7)	X						X	159		15.0		

Figure A-2. OV-10A Aircraft Configuration Table (Sheet 1 of 3)

OV-10A

NOTE: IN CASE OF MIXED STORES USE HIGHEST DRAG INDEX

ITEM	STATION L	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION R	WEIGHT LBS FULL	WEIGHT LBS EMPTY	DRAG NUMBER SINGLE	DRAG NUMBER ADJACENT	DRAG NUMBER MULTIPLE
2.75 INCH ROCKET LAUNCHERS												
LAU-61A/A, B/A, C/A (WITH FAIRINGS)		X	X		X	X		711 MAX 458 MIN*		10.0	17.0	22.0
W/O FAIRINGS (FULL)										29.0	35.0	40.0
EMPTY									155	12.0	18.0	23.0
LAU-68B/A, D/A (WITH FAIRINGS)		X	X		X	X		258 MAX 186 MIN*		4.0	5.0	6.0
W/O FAIRINGS (FULL)										15.0	16.0	17.0
EMPTY									80	5.0	6.0	7.0
5.0 INCH ROCKET LAUNCHERS												
LAU-10 SERIES (WITH FAIRINGS)		X	X		X	X		696 MAX 555 MIN*		7.0	11.0	15.0
W/O FAIRINGS (FULL)										26.0	33.0	34.0
EMPTY									142	9.0	13.0	17.0

*ROCKET POD FULL WEIGHT DEPENDS ON POD VERSION, ROCKET MOTOR, WARHEAD AND FUZE

Figure A-2. OV-10A Aircraft Configuration Table (Sheet 2 of 3)

OV-10A

NOTE: IN CASE OF MIXED STORES USE HIGHEST DRAG INDEX

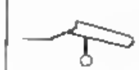
ITEM	STATION L	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION R	WEIGHT LBS FULL	WEIGHT LBS EMPTY	DRAG NUMBER SINGLE	DRAG NUMBER ADJACENT	DRAG NUMBER MULTIPLE
GUN PODS												
GPU 2A (M197 GUN)			X		X			586	[illegible]	20.0		33.0
PARACHUTE FLARE DISPENSERS												
SUU 25 F A EIGHT LUU 2A B B B		X	X	X	X	X		492	260	8.0	13.0	17.0
SUU 44 A EIGHT LUU 2A B B-B, Mk 45		X	X	X	X	X		304	128	8.0	13.0	17
SEISMIC SENSORS												
A A37/B 3 (PMBR) SIX ADSID III (S)		X				X		321	87	10.0 70.0	12.0 96.0	14.0 112.0
OR THREE ADSID III (N)		X	X	X	X	X		204		50.0	80.0	

Figure A-2. OV-10A Aircraft Configuration Table (Sheet 3 of 3)

OV-10D

CLEAN AIRCRAFT (SPONSONS, C.L. RYLON AND FLIR TURRET) DRAG = 50*

NOTE: IN CASE OF MIXED STORES USE HIGHEST DRAG INDEX

ITEM	STATION							WEIGHT-LBS		DRAG NUMBER		
	t	1	2	3	4	5	A	FULL	EMPTY	SINGLE	ADJACENT	MULTIPLE
AIRCRAFT OPERATING WEIGHT									9 816			
INCLUDES												
SPONSONS (TWO) WITH RACKS								272		21.0		
CENTERLINE PYLON				X				52		4.5		
GENERAL ITEMS												
USABLE INTERNAL FUEL JP-5								1 622				
WING STATION PYLONS (TWO)	X						X		132	15.0		
AUXILIARY FUEL TANKS (TWO) (JP-5)	X						X	1 538	232	27.0		
AERO-1C OR FPU-3A (JP-5)				X				1 155	135	14.0		24.0
AERO-1D (JP-5)				X				2 229	189	14.0		
230 GALLON TANK (JP-5)				X					246	12.0		21.0
M60C GUNS (FOUR) COMPLETE									150			
AMMUNITION 2000 ROUNDS								130				
GENERAL PURPOSE BOMBS												
MK 81 WITH MAU-91 CONICAL FINS		X	X	X	X	X		260		[illegible]	5.0	6.0
MK 81 WITH MK 14 LOW HIGH DRAG FIN		X	X	X	X	X		305		6.5	7.5	9.0
MK 82 BDU-45 B WITH MAU-93 BSU-33 CONICAL FIN		X	X	X	X	X		531		5.0	6.0	7.0
MK 82 BDU-45 B WITH MK 15 LOW HIGH DRAG FIN		X	X	X	X	X		565		9.0	10.0	11.0
MK 83 CONICAL FIN				X				985		[illegible]	10.5	12.0
FIRE BOMBS												
MK 77 MOD 4-5		X	X	X	X	X		520		8.0	10.0	12.0
CLUSTER BOMBS												
CBU-55 B (FAE) OR CBU-55A B (FAE)	X	X	X	X	X	X	X	519		13.0	20.0	27.0
PRACTICE BOMBS												
A/A37B-3 (PMBR)									87.0	10.0	12.0	14.0
SIX MK 76, BDU-33 D B		X	X	X	X	X		237	87.0	18.5	25.0	32.0
SIX MK 106, BDU-48 B		X	X	X	X	X		[illegible]	87.0	25.0	34.0	45.0
MISSILES												
AIM-9 (WITH LAU-7 AND ADU-299)	X						X					
FULL								310		16.0		
FIRED									[illegible]	6.0		
TACTS (WITH LAU-7 AND ADU-299)	X						X	187		15.0		

Figure A-3. OV-10D Aircraft Configuration Table (Sheet 1 of 3)

OV-10D

NOTE: IN CASE OF MIXED STORES USE HIGHEST DRAG INDEX

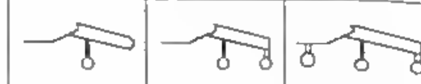
ITEM	STATION L	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION R	WEIGHT-LBS FULL	WEIGHT-LBS EMPTY	DRAG NUMBER SINGLE	DRAG NUMBER ADJACENT	DRAG NUMBER MULTIPLE
2.75 INCH ROCKET LAUNCHERS								711 MAX				
LAU-61A/A, B/A, C/A (WITH FAIRINGS)		X	X		X	X		458 MIN*		10.0	11.0	22.0
W/O FAIRINGS (FULL)										29.0	35.0	40.0
EMPTY									155	12.0	18.0	23.0
								258 MAX				
LAU-68B/A, D/A (WITH FAIRINGS)	X	X	X		X	X	X	186 MIN*		4.0	5.0	6.0
W/O FAIRINGS (FULL)										15.0	16.0	17.0
EMPTY									80	5.0	6.0	7.0
[illegible] INCH ROCKET LAUNCHERS								696 MAX				
LAU-10 SERIES (WITH FAIRINGS)	X	X	X		X	X	X	555 MIN*		7.0	11.0	15.0
W/O FAIRINGS (FULL)										26.0	30.0	34.0
EMPTY									142	9.0	13.0	11.0

*ROCKET POD FULL WEIGHT DEPENDS ON POD VERSION, ROCKET MOTOR, WARHEAD AND FUZE

Figure A-3. OV-10D Aircraft Configuration Table (Sheet 2 of 3)

OV-10D

NOTE: IN CASE OF MIXED STORES USE HIGHEST DRAG INDEX



ITEM	STATION							WEIGHT LBS		DRAG NUMBER		
	L	1	2	3	4	5	R	FULL	EMPTY	SINGLE	ADJACENT	MULTIPLE
GUN PODS												
GPU-2/A (M197 GUN)			X		X			586	417	20.0		13.0
PARACHUTE FLARE DISPENSERS												
SUU-44/A WITH 8 LUU-2A/B, B/B, MK 45	X	X	X	X	X	X	X	368	128	8.0	13.0	[illegible]
SUU-25F/A WITH 8 LUU-2B/B	X	X	X	X	X	X	X	490	266	8.[illegible]	13.0	[illegible]
SEISMIC SENSORS												
A/A37B-3 (PMBR)									87	10.0	12.0	14.0
SIX ADSID III (S)		X				X		327		70.0	96.0	112.0
THREE ADSID III (N)		X		X		X		204		50.0	80.0	
OR			X		X							

Figure A-3. OV-10D Aircraft Configuration Table (Sheet 3 of 3)

APPENDIX B

Maps and Aerial Photos

B.1 MAP READING

Since maps and map substitutes are a primary fighting instrument of the commander of any unit and play a vital part in military operations, the ability to read, understand, and use them is an important professional qualification. Proficiency in map reading results from a study of the principles and development of technique through practice.

B.1.1 Definition of a Map. A map is a line drawing to scale of a portion of the Earth's surface as seen from above.

B.1.2 Marginal Information. Marginal information appears in the margin of a map. It gives details of a technical nature that must be considered if the map is to be used effectively. Although the amount of information varies in detail and degree, the following usually appears:

1. The name or title of the sheet

2. The sheet number

3. An index showing adjacent map sheets

4. The declination diagram, indicating the direction and relationship of True, Magnetic, and Grid North.

5. The scale of the map, expressed as a representative fraction (RF), and in graphic scale

6. The contour interval

7. The grid reference box

8. The agencies that prepared or supervised the original map and/or subsequent revisions

9. The date compiled and field checked

10. A legend.

Marginal information indicates the uses and limitations as well as the accuracy and reliability of a map.

B.1.3 Topographic Symbols. Topographic symbols and standard drawings by which mapped features are shown on a map. To increase the value and for ease of identification, topographic symbols have distinctive colors. The following colors are standard:

1. BLACK — manmade objects; i.e., road, building, mine.

2. RED — road classification and some manmade features, such as large built-up areas

3. BLUE — drainage; i.e., river, lake, swamp

4. GREEN — vegetation; i.e., orchard, grassland, woods.

5. BROWN — elevation and relief; i.e., contour lines, hachures.

B.1.4 Military Symbols. Military symbols are drawings which represent types of military organizations, activities, and installations on maps, charts, and overlays. They are identified in Figure B-1. The following colors are standard:

1. BLUE — friendly forces

2. RED — enemy forces

3. GREEN — engineer obstacles, both friendly and enemy

4. YELLOW — contaminated areas (C.B.R.) both friendly and enemy.

When colors are not available, single lines are used to represent friendly forces and double lines to represent enemy forces.

B.1.5 Military Grid Systems. A military grid system is a network of squares formed by North-South and East-West gridlines placed on a map. The distance between gridlines is 1,000 or 10,000 meters, depending upon the scale of the map. The purpose of the grid system is to enable the map reader to quickly and

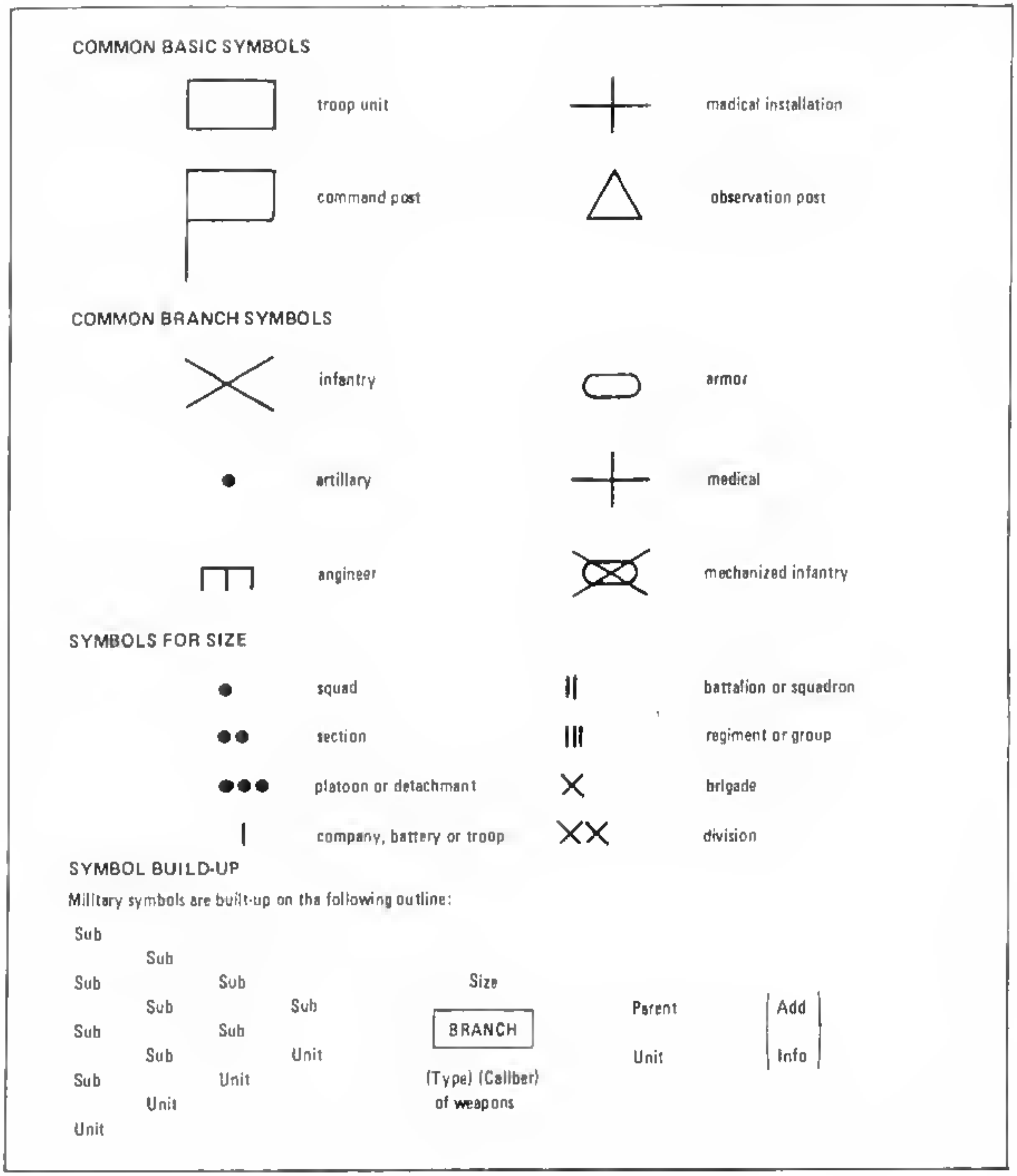


Figure B-1. Military Symbols (Sheet 1 of 5)

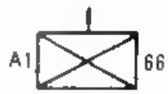
SYMBOL BUILD-UP (Continued)

This example illustrates the method of building up a military symbol:

This is a troop unit.

This is an infantry troop unit.

This is the 1st Battalion, 66th Infantry.



This is Company A, 1st Battalion, 66th Infantry.

This is 1st Platoon, Company A, 1st Battalion, 66th Infantry.

This is 2nd Squad, 1st Platoon, Company A, 1st Battalion, 66th Infantry.

NOTE: When colors are not available, single lines are used for friendly forces and double lines for enemy forces.

Friendly troop unit

Enemy troop unit

IDENTIFICATION SYMBOLS

Some units can only be identified by the weapon employed. The following are symbols for crew-served weapons, weapons characteristics, and roles in which weapons may be employed.

Crew-Served Weapon, Infantry (basic symbol)

Crew-Served Weapon, Artillery (basic symbol)

Figure B-1. Military Symbols (Sheet 2 of 5)

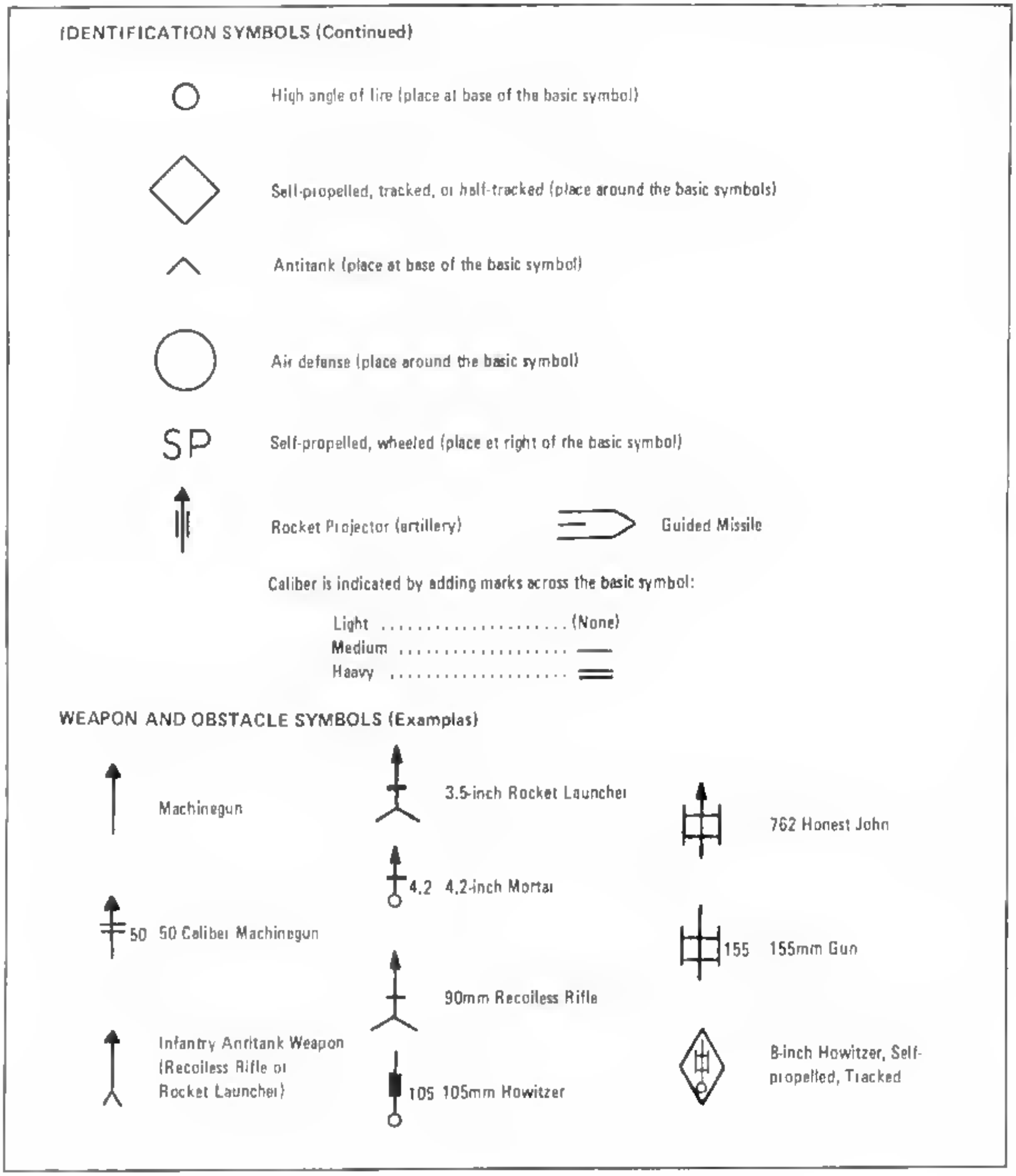


Figure B-1. Military Symbols (Sheet 3 of 5)

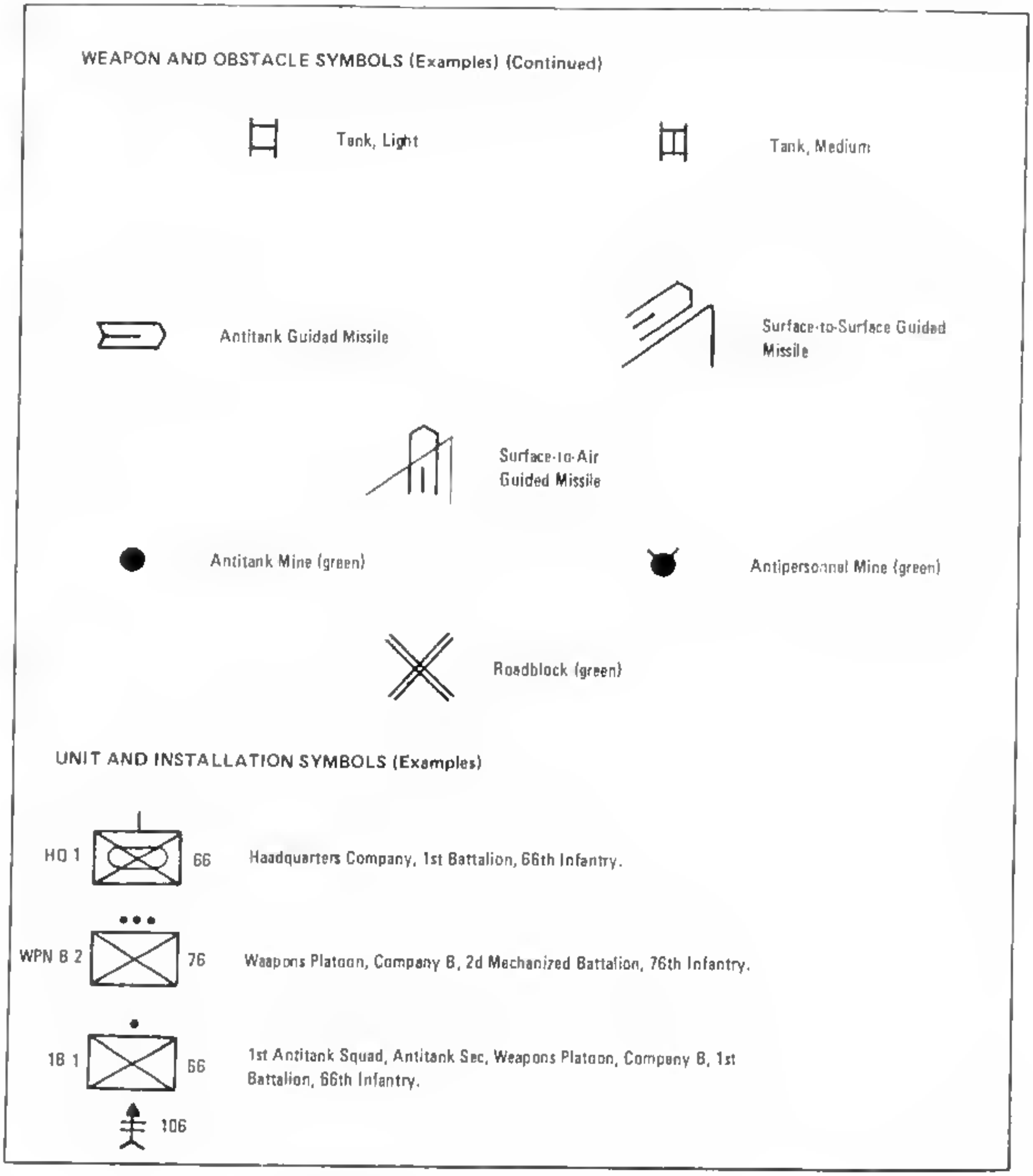
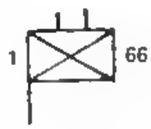


Figure B-1. Military Symbols (Sheet 4 of 5)

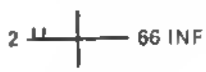
UNIT AND INSTALLATION SYMBOLS (Examples) (Continued)



Command Post, 1st Battalian, 66th Infantry.

Observation Post Company B, 1st Battalion, 66th Infantry .

Communication Platoon, Headquarters Company, 1st Battalion, 66th Infantry.



Aid Station, 2nd Battalion 66th Infantry.

Maintainance Platoon, Headquartars Company, 1st Battalion, 66th Infantry.

Proposed Location, Company C, 1st Battalion, 66th Infantry.

Figure B-1. Military Symbols (Sheet 5 of 5)

accurately locate a point on the map. Gridlines are identified by a specific number printed in the margin directly opposite the line it indicates. Any point on a map can be identified by means of grid coordinates. The rules for reading grid coordinates are:

1. Use only the large bold-face numbers in the margin labeling each gridline.

2. Start at the lower left hand corner of the map sheet and read RIGHT and UP.

3. Write the coordinate as a continuous series of numbers. The first half of the total number of digits represents the RIGHT reading; the last half represents the UP reading.

See Figure B-2 for examples of reading grid coordinates.

B.1.5.1 The Universal Transverse Mercator (UTM). The universal transverse mercator (UTM) grid system covers that portion of the world between 84° North latitude and 80° South latitude. It divides the area in 60 grid zones each 6° wide. The grid zones are numbered 1 thru 60. Each of these grid zones is further subdivided into segments that are 8° high. These 6° by 8° segments are called grid zone designations and are identified by the grid zone number and a letter which appear in the grid reference box in the margin of the map.

B.1.5.2 The Military Grid Reference System (MGRS). The military grid reference system (MGRS) is based on the UTM grid. The MGRS superimposes upon the UTM grid zone designation a system of 100,000 meter grid squares which are identified by two letters. For example, 16SGL preceding a coordinate indicates that the point lies in grid zone designation 16S and 100,000 meter square GL. Grid coordinates must be prefixed by the 100,000 meter square identification consisting of two letters. The grid reference box in the margin of the map indicates the 100,000 meter square identification.

B.1.6 Scale. Scale is the fixed relationship between map distance and ground distance. It is expressed as:

1. A representative fraction (RF):

$$RF = \frac{\text{MD (map distance)}}{\text{GD (ground distance)}}$$

RF appears in the margin of the map as

$\frac{1}{50,000}$, 1/50,000, or 1:50,000, all of which means that 1 unit of measure on the map represents 50,000 similar units of measure on the ground.

2. Graphic scale: This scale is printed in the margin as a special ruler and is used to measure ground distances on a map. Military maps normally have graphic scales in miles, meters, and yards.

B.1.7 Distance. To measure straight line ground distance on a map place a straight strip of paper on the map between the two points. Mark the paper opposite the center of each of the two points. Place the paper on the appropriate graphic scale at the bottom of the map and read the distance.

To measure road distance between two points, use a straight strip of paper. Divide the road into small, straight line sections, each time marking the straight line sections consecutively along the strip of paper. Place the paper, which contains the total length of all the straight line sections, on the graphic scale, and read the distance.

Remember:

1. Measure to center of mass

2. Use correct graphic scale

3. In measuring road distance, measure on one side of the road.

B.1.8 Direction (Azimuth). Direction is an imaginary straight line on the map or ground called an azimuth. An azimuth is a horizontal angle measured clockwise from the base direction. All directions originate from the center of an imaginary circle called the azimuth circle. This circle is divided into 360 equal units of measurement called degrees. They are numbered in a clockwise direction, with zero at North, East at 90°, West at 270°, and North at 360° (or 0°). Distance has no effect on azimuth. The azimuth of line UC is the same as line UB.

The back azimuth of a line differs from its azimuth by exactly 180°. The rules for determining back azimuth are:

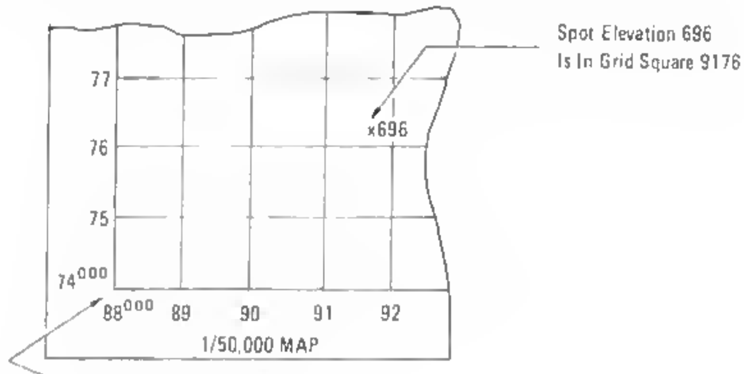
1. If the azimuth is less than 180°, the back azimuth is the value of the azimuth plus 180°.

2. If the azimuth is more than 180°, the back azimuth is the value of the azimuth minus 180°.

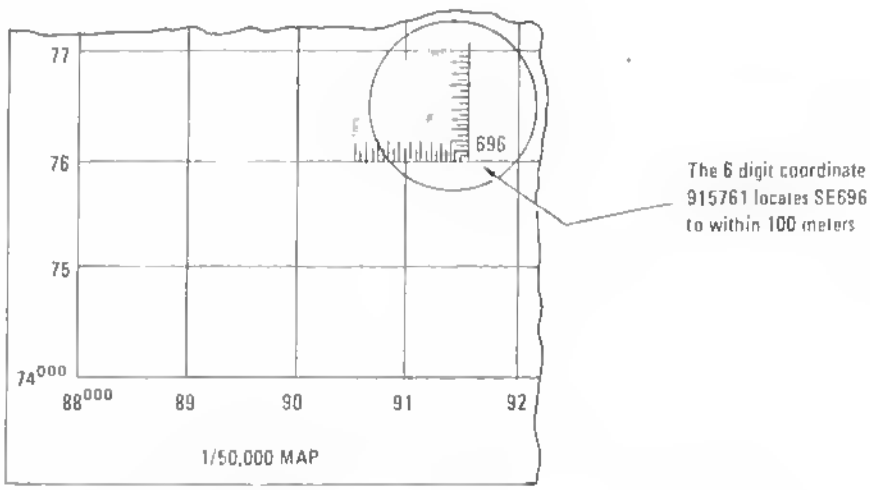
3. If the azimuth is 180°, the back azimuth is 0°or 360°.

READING FROM MAP WITH 1,000 METER GRID SQUARES

To locate a point used to designate an object easily identifiable within a large area, identify the grid square by the numbers of the two grid lines which intersect at the lower left hand corner; e.g., 9176.



To locate the same point within 100 meters:



1. Use the appropriate corner of the coordinate card which breaks the 1,000-meter square into 10 equal parts along each side (the longer lines on the scale).

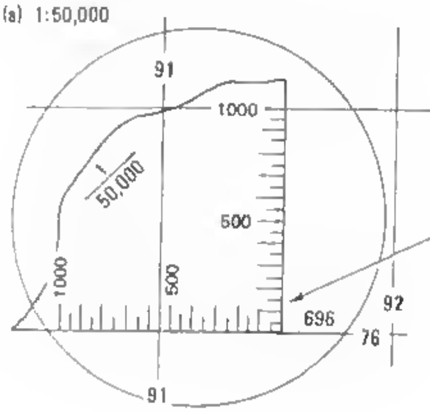
Figure B-2. Grid Coordinates (Sheet 1 of 2)

2. Place the coordinate card along the East-West grid at the lower left hand corner of the grid square, then slide it eastward to the center of the object.

3. Express the location using six digits: the third digit is the longer line on or to the right of grid line 91; the sixth digit is the longer line on or below the SE number; e.g., 915761.

To locate the point within 10 meters:

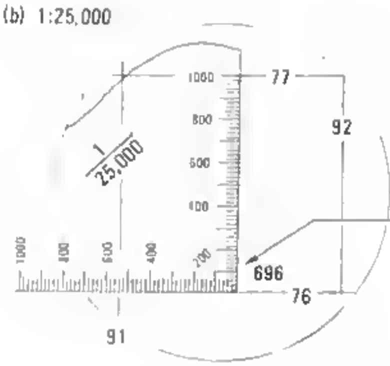
(a) 1:50,000



Short lines divide the 100-meter segment into 50-meter segments. To read to nearest 10 meters, interpolate along scale.

The 8 digit coordinate 91547614 locates SE 696 to within 10 meters.

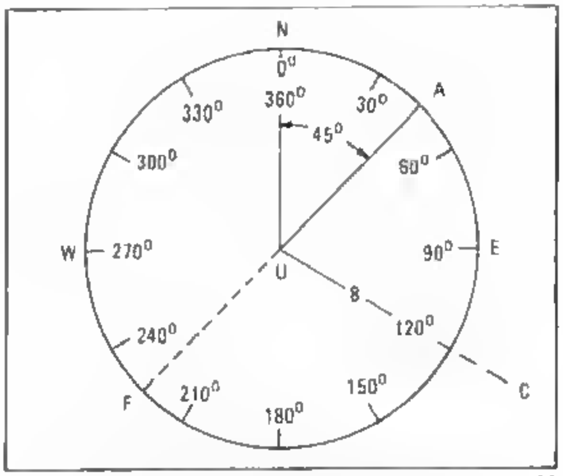
(b) 1:25,000



Short lines divide the 100-meter segment into 20-meter segments. To read to nearest 10 meters, interpolate along the scale.

The 8 digit coordinate 91547614 locates SE696 to within 10 meters.

Figure B-2. Grid Coordinates (Sheet 2 of 2)



Line UF is the back azimuth of line UA (45° + 180° = 225°).

Map azimuths are measured with a protractor. To read a map azimuth between any two points:

1. Plot a line connecting the two points.

2. Place the index mark of the protractor at the point from which you are measuring, ensuring that the 0° to 180° line of the protractor is on, or parallel to, a North-South gridline. Read the azimuth at the point at which the line intersects the scale.

To plot an azimuth on a map:

1. Place the protractor on the map with the index mark at the initial point and the 0° to 180° line parallel to a North-South gridline.

2. Place a dot on the map at the desired azimuth on the scale.

3. Remove the protractor and connect the initial point and the dot with a straight line.

B.1.9 Base Direction. There are three base directions: True North, Grid North, and Magnetic North. The angular relationships among these three directions are shown by a declination diagram in the margin of the map. An explanation of the base directions follows:

1. True North — the direction to the North Pole, the symbol for which is a star

2. Grid North — the direction of the North-South gridlines, the symbol for which is GN

3. Magnetic North — the direction in which the magnetic arrow of the compass points, the symbol for which is a half arrow.

B.1.10 Grid Magnetic (G-M) Angle. Grid North is used to read grid azimuths (protractor and map) and Magnetic North is used to read magnetic azimuths (compass and ground). These base directions are used to determine G-M Angle:

1. Grid azimuth — a horizontal angle measured clockwise from Grid North

2. Magnetic azimuth — a horizontal angle measured clockwise from Magnetic North

3. G-M angle — the angular difference between Grid North and Magnetic North, measured from Grid North.

To use a grid azimuth in the field with a compass, change it first to a magnetic azimuth. To plot a magnetic azimuth on a map, change it first to a grid azimuth. To make either of these changes, use a G-M angle diagram. Construction and use of this diagram are illustrated in Figure B-3.

The G-M angle diagram should be constructed and used each time conversion of azimuths is required. Such a procedure is particularly important when working with a map for the first time or when an annual magnetic change occurs. As a time saving procedure when working frequently with the same map, construct a G-M angle conversion table on the margin of the map. An example of this table follows:

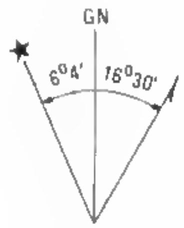
FOR CONVERSION OF:
MAG AZ TO GRID AZ: SUBTRACT 12°
GRID AZ TO MAG AZ: ADD 12°

B.1.11 Polar Coordinates. This is a method of locating or plotting a point by azimuth (direction) and distance from a known starting point. The azimuth is grid or magnetic. The distance is normally expressed in miles, meters, or yards.

B.1.12 Intersection. Distant objects can be located on a map by intersecting lines from two known points. For example, a magnetic azimuth from a known observation post to a distant point is converted to a grid azimuth and drawn on the map. Another magnetic azimuth from another known observation post to the same distant point is converted to a grid azimuth and drawn on the same map. The intersection of the two lines on the map is the location of the distant point.

CONSTRUCTING THE DIAGRAM

1. Refer to the declination diagram on the map and extract the G-M angle. Bring it up to date. Below is a sample declination diagram and an explanation of how to figure the current G-M angle.



Approximate Mean Declination 1949

For Center of Sheet

Annual Magnetic Change 2° Westerly

Figuring for the year 1963, the G-M angle has been changing 14 years. It has changed 2 minutes each year, and has changed a total of 28 minutes. According to the diagram, Magnetic North has been moving toward Grid North, so the change must be subtracted from the original G-M angle. 16° 30' - 28' = 16° 2'. Now round off the G-M angle to the nearest 1/2 degree. (0' to 14' = 0 degrees; 15' to 44' = 1/2 degree; 45' to 60' = 1 degree.) The G-M angle for the declination diagram above is 16° East.

2. Draw the current G-M angle.

3. From the base of the G-M angle, draw a line to the right; this line represents any azimuth.

4. From Grid North draw an arc to the any azimuth line and label it G for grid azimuth. From Magnetic North draw an arc to the any azimuth line and label it M for magnetic azimuth.

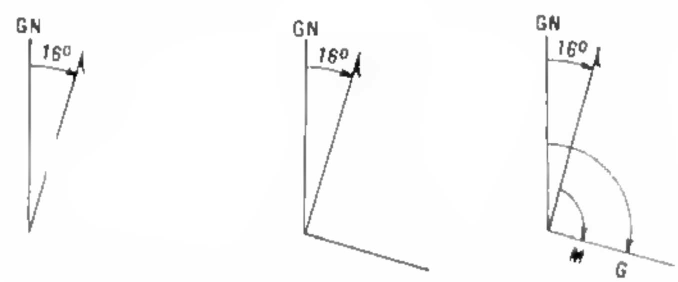
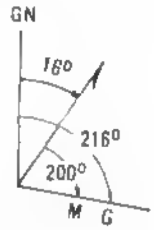


Figure B-3. G-M Angle Diagram (Sheet 1 of 3)

USING THE DIAGRAM—EAST G-M ANGLE

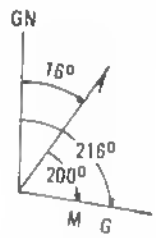
When working with a map which has an East G-M angle:

1. Convert magnetic azimuth to grid azimuth.



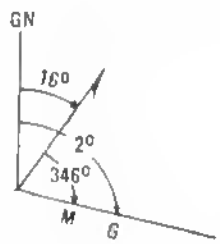
MAGNETIC AZIMUTH = 200°
G-M Angle = 16° E
Grid Azimuth = 216°

2. Convert grid azimuth to magnetic azimuth.



GRID AZIMUTH = 216°
G-M Angle = 16° E
Magnetic Azimuth = 200°

3. Convert grid azimuth to magnetic azimuth when the G-M angle is greater than Grid Azimuth.



GRID AZIMUTH

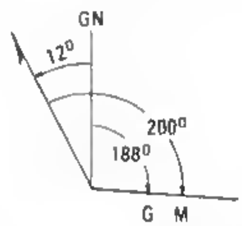
GRID AZIMUTH = 2°
G-M Angle = 16° E
Since 0°=360°; 2° = 362°
\- 16°
Magnetic Azimuth = 346°

Figure B-3. G-M Angle Diagram (Sheet 2 of 3)

USING THE DIAGRAM—WEST G-M ANGLE

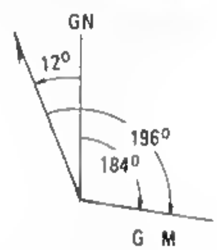
When working with a map which has a West G-M Angle:

1. Convert magnetic azimuth to grid azimuth.



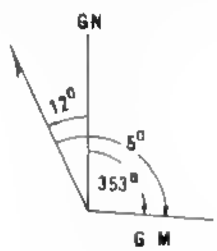
MAGNETIC AZIMUTH = 200°
G-M Angle = 12° W
Grid Azimuth = 188°

2. Convert grid azimuth to magnetic azimuth.



GRID AZIMUTH = 184°
G-M Angle = 12°W
Magnetic Azimuth = 196°

3. Convert magnetic azimuth to grid azimuth when the G-M angle is greater than magnetic azimuth.



MAGNETIC AZIMUTH = 5°
G-M Angle = 12°W
Since 0° = 360°; 5° =365°
-12°
Grid Azimuth = 353°

Figure B-3. G-M Angle Diagram (Sheet 3 of 3)

B.1.13 Resection. This is a method of locating one's position on a map. Magnetic azimuths are taken to two distant points on the ground which can be identified on the map. Convert them to grid azimuths and change grid azimuths to back azimuths, then draw the back azimuths from the known points on the map. The intersection of the two lines is your location. To verify the map location, make a final determination of your position by inspection; i.e., compare ground features with those shown on the map.

B.1.14 Modified Resection. This is a method of locating one's position on the map when you are located on a road, stream, or other linear feature identified on the map. A magnetic azimuth is taken to a distant point on the ground which can be identified on the map. Convert to grid azimuth and change grid azimuth to back azimuth, then draw the back azimuth from the known point on the map.

The point that the line intersects the linear feature is your location. To verify the map location, make a final determination of your position by inspection; i.e., compare ground features with those shown on the map.

B.1.15 Terrain Association. One of the most important functions of a map is to convey graphically to the map reader a portion of the Earth's surface; therefore, the ability to study a map and visualize terrain features, not as topographic symbols, but as actual ground forms, must be acquired. To reach this goal a thorough knowledge of elevation and relief is essential.

B.1.16 Elevation and Relief. Elevation is vertical distance in feet or meters above or below mean sea level. Relief is the variation in the height and shape of the Earth's surface. Elevation and relief may be indicated on a map by hachures, layer tinting, or contour lines. Contour lines are used on large scale maps.

Contour lines are imaginary lines on the ground that connect points of equal elevation. On a map they are shown in brown or gray. The contour interval, which is the vertical distance between contours, is stated as marginal information. Normally every fifth contour is printed more heavily than the others and is numbered to show the height above or below mean sea level. This line is known as the index contour. Some characteristics of contours are:

1. Contours are smooth curves which always close.

2. Contours close together indicate a steep slope; contours far apart indicate a gentle slope.

3. On uniform slopes contours are evenly spaced; on irregular slopes contours are unevenly spaced.

4. Movement parallel to contours is relatively level; movement across contours is up or down slope.

Occasionally the contour interval is too large to show significant topographic formations. When this occurs broken brown lines, called auxiliary or supplementary contours, are added at one half the contour interval.

B.1.17 Terrain Features. All terrain may be classified into one of the following basic terrain features: hilltop, ridge, valley, saddle, or depression. The relationships of contour lines and terrain features are illustrated in Figure B-4.

To determine the elevation of a point that falls between two adjacent contours, estimate the relative distance of the point between the two contours and add it to the elevation of the lower-valued contour line. For example, a point located seven-tenths of the distance between the 70-foot and the 80-foot contours would have an elevation of 77 feet. To determine the elevation of a hilltop, take the elevation of the last closed contour and add to it one-half the contour interval. To determine the elevation of a depression, subtract one-half the contour interval from the last depression contour.

B.2 AERIAL PHOTOGRAPH READING

An aerial photograph is a picture of the Earth's surface, taken from above, which may be used for intelligence on enemy and terrain, to plan tactical operations, or as a map substitute or map supplement.

B.2.1 Types

1. According to position of camera:

   (a) Vertical — a photograph made with the axis of the camera perpendicular or vertical to the Earth's surface at the time of exposure

   (b) Oblique — a photograph made with the axis of the camera tilted from the vertical. A high oblique photograph includes part of the horizon; a low oblique photograph does not include the horizon.

2. According to method of reproduction:

   (a) Contact print — copies printed individually from a negative with details clearly shown.

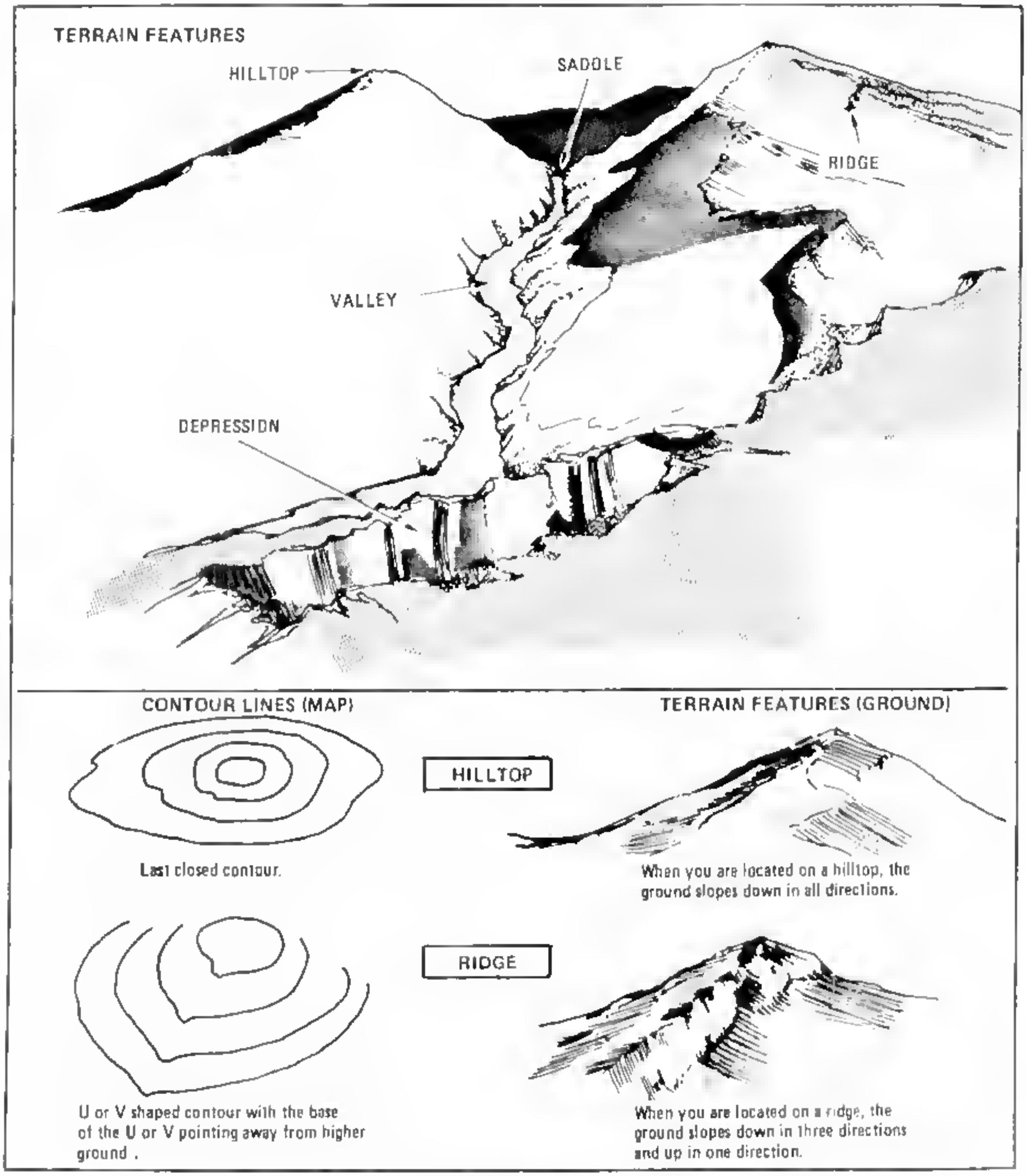


Figure B-4. Contour Lines and Terrain Features (Sheet 1 of 2)

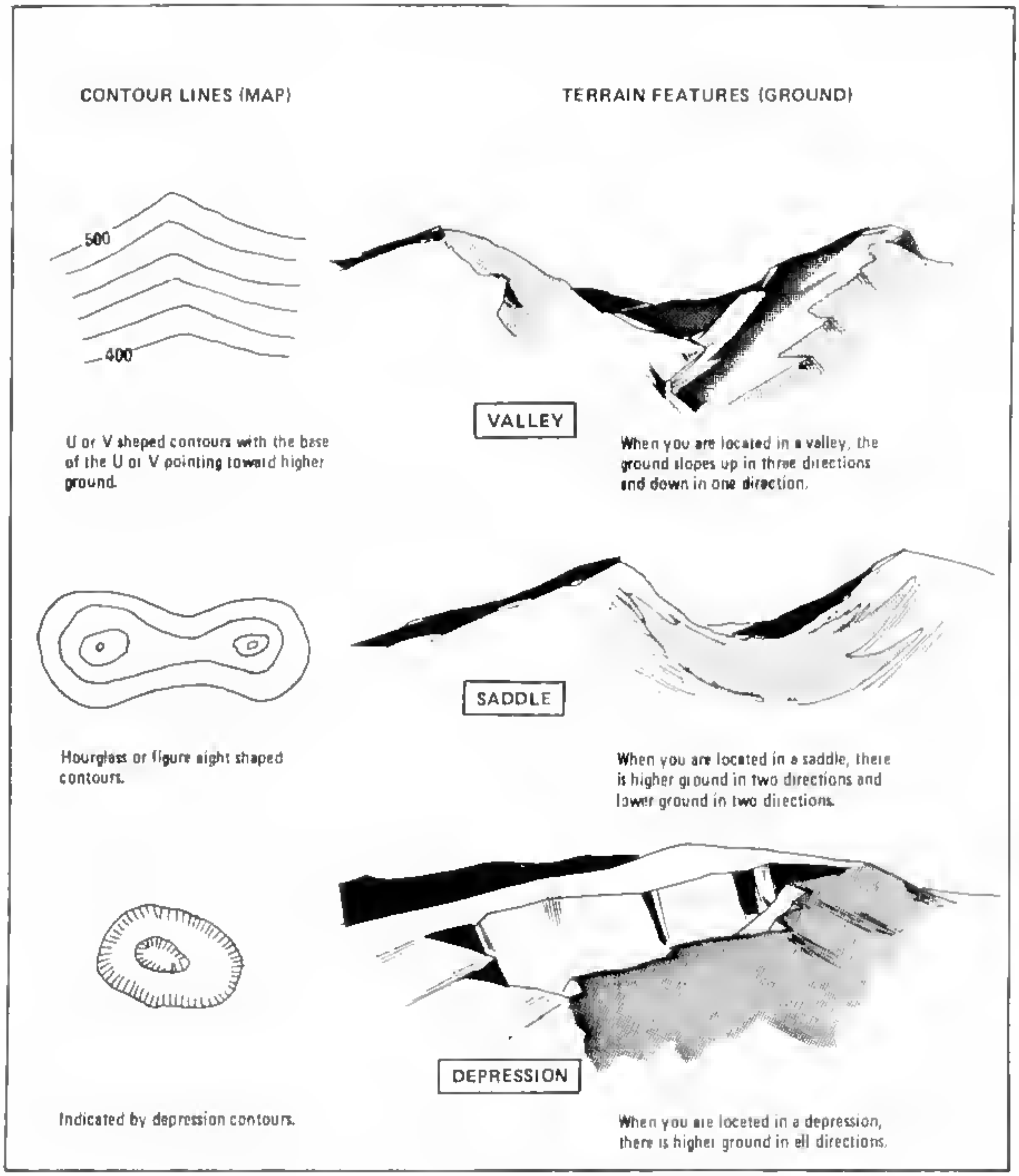


Figure B-4. Contour Lines and Terrain Features (Sheet 2 of 2)

(b) Halftone — a lithographic reproduction similar to a newspaper picture with details not as clear as on a contact print.

B.2.2 Strip. A series of overlapping vertical photographs made from an airplane flying a selected flight line or direction. The photographs on a strip may be used for sterographic study or matched and secured in place to form a strip mosaic.

B.2.3 Mosaic. A composite photograph consisting of a series of overlapping vertical photographs, either contact prints or halftones, joined together. An uncontrolled mosaic is a mosaic in which several vertical photos have been oriented with respect to each other and joined together with little regard to true ground scale. A controlled mosaic is a mosaic in which several vertical photos are brought to a uniform scale, oriented with respect to each other, and fitted to the plotted position of ground control points.

B.2.4 Comparison of Aerial Photographs and Maps

1. Topography: On a map, topographic detail is shown by topographic symbols. Aerial photos show topographic detail as a picture, exactly as it appears from above.

2. Scale: Map scales are standard and constant. The scale of aerial photos varies and is not constant for an entire photo because of distortion.

3. Marginal information: On a map, marginal information is detailed and standard. It is generally incomplete in an aerial photo.

4. Elevation and relief: On a map, relief and elevation are portrayed by contour lines. They are not readily apparent in an aerial photo.

5. Preparation: A map requires a long time to prepare and reproduce, and the terrain must be accessible to the mapmaker. An aerial photo of an area can be obtained and developed in a short time, and may be made of areas otherwise inaccessible for physical or military reasons.

6. Current information: A map becomes somewhat outdated because of gradual changes in the terrain and constant changes in manmade features indicated on the map. A recent aerial photo is an up-to-date picture of the terrain, sometimes only a few hours old.

B.2.5 Photo Interpretation. The photoreader must be proficient in identification. He must be able to identify topographic features in order to properly use a photo as a map substitute or map supplement. Practice in the identification of features and objects as seen on an aerial photo is the only way to become proficient.

To identify objects on a vertical photo, orient it so that the shadows fall toward the viewer (shadows stab stomach). To identify objects on an oblique photo, orient it so that you are in the same relative position as the camera which took the picture. Five considerations in identifying a feature are size, tone, shape, shadow, and relationship of feature to surrounding features.

B.2.6 Orientation of Photograph to Map or Ground. Study of a photograph is greatly facilitated by comparison with a map or the ground of the same area. In comparing the two, orient the photograph to the map or the ground. This is most readily done by comparing such features as road nets, stream systems, or other outstanding or unusual features.

B.2.7 Use of an Aerial Photograph as a Map Supplement. The advantageous characteristics of a current aerial photograph provide a valuable supplement to a topographic map. When used as a map supplement, the aerial photograph may or may not be gridded as the situation demands. It is often necessary to compare a point location on a map with the same point on an aerial photograph. To do this, use the following method:

1. Orient the aerial photograph to the map by inspection:

(a) When the general area of the photo is known, the specific location of the photo on the map may be found as in paragraph B.2.7.

(b) When the general area of the photo is unknown, specific location may be determined by using the geographic coordinates which usually appear in the legend of the photo.

(c) Align identifiable features on the photograph with the same features on the map.

(d) Take into consideration the difference in scale between the map and the aerial photograph.

2. Find the point on the map and designate it using MGRS coordinates.

3. Find the same point on the aerial photograph and designate it using point designation (PD) coordinates (if the aerial photograph is gridded).

B.2.8 Use of an Aerial Photo as a Map Substitute. A photomap is a reproduction of a photograph or mosaic on which gridlines, marginal data, and place names are added. For use, a photomap must have the following: grid system, scale, and G-M angle. Controlled mosaics are brought to a uniform scale and are normally overprinted with the MGRS grid system.

B.2.9 Point Designation (PD) Grid. Printing of an accurate grid on vertical photos and uncontrolled mosaics is impractical because of scale distortion, so an arbitrary grid known as the point designation (PD) grid is used. This grid has no relation to actual scale or orientation of the photograph. It serves only for point designation. The grid interval is always 4 centimeters or 1.575 inches. The steps in constructing the PD grid are:

1. Turn the photograph so that the legend or photo number is in the normal reading position.

2. Draw lines connecting opposite fiducial marks (half arrows). If there are not fiducial marks, the center of each side of the photograph is assumed to be the location of the marks.

3. Label both of these lines as 50.

4. Draw additional gridlines parallel to the two 50 gridlines, 4 centimeters apart. The 1/25,000 corner of the coordinate card may be used for this purpose, since the length of this scale is 4 centimeters.

Note

This does not mean that the photograph is in the scale of 1:25,000.

5. Extend the grid past the lower left corner of the photograph so that a horizontal and a vertical grid line fall outside the area of the picture.

6. Give numerical values to the remaining grid lines so that they decrease to the right and up.

7. For greater accuracy, repeat the above procedure using several different points. Average the denominators of the several representative fractions to get an average scale.

B.2.10 Determining Length of Graphic Scale. The fixed relationship between ground distance and photo distance is expressed by a representative fraction (RF):

$$RF = \frac{\text{PD (photo distance)}}{\text{GD (ground distance)}}$$

If the RF of the photograph is 1/12,300, then:

1/12,300 = PD (m)/1,000m or PD (cm)/1,000 m X 100 cm

1/12,300 = PD/100,000 cm = 1 cm/100,000 cm

100,000 cm/12,300 = 8.1 cm

On the photo in this example, 8.1 cm represents 1,000 m on the ground. To determine the length of a graphic scale for 1,000 yards or 1 mile, substitute 1,000 yards or 1 mile for ground distance in the above formula.

B.2.11 Determination of G-M Angle. PD Grid North is established when the PD grid is constructed. It is then necessary to plot magnetic North and determine the G-M angle.

When on the ground with no map available, use a compass to determine the magnetic azimuth between two points that can be easily identified on both the ground and the photograph. Draw a line on the photo between the two points. Place the index of the protractor at the point on the photo which this line crosses North-South grid line. Rotate the protractor until the measured azimuth on the scale falls over the line connecting the two points and then draw a line along the base of the protractor. This line represents the base direction of Magnetic North. Now read the scale of the protractor where the North-South gridline cuts the scale to obtain the degree reading. Your direction will be determined by the position of Magnetic North in relation to Grid North.

When comparing the photo with a map, use a line between two points that can be easily identified on both the map and the photograph. Determine the grid azimuth of this line from the map and convert it to magnetic azimuth. Place the index of the protractor at the point on the photo at which this line crosses a North-South grid line. Rotate the protractor until the measured azimuth on the scale falls over the line connecting the two points and then draw a line along the base of the protractor. This line represents the base direction of Magnetic North. Now read the scale of the protractor where the North-South gridline cuts the scale to obtain the degree reading. Your direction will be determined by the position of Magnetic North in relation to Grid North.

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